Hawaii Trail Analysis

Survey & Risk Management Data Profile

This Final Report prepared for:

Department of Land and Natural Resources
Risk Assessment Working Group

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Executive Summary

In the Fall of 2000, a sample trail analysis was conducted at selected Hawaii State Parks and Na Ala Hele trails on four islands. The objective was to generate data on user profiles as well as descriptive information of the trail features, and interpret this into information to be used toward the development of a comprehensive inventory of trail data and ultimately an environmental and recreation risk management plan. The Hawaii Trail Analysis was conducted by five graduate students at the University of Hawaii, Department of Urban and Regional Planning under the guidance of Professor Peter Flachsbart. Funding for the project was provided by the Physical Activity Promotion Project in the Hawaii Department of Health (DOH).

A combination of fourteen trails and parks made up the survey area, four each on Oahu, Kauai and the Big Island, and two on Maui. Trail selection was made through consultation with Department of Land and Natural Resources (DLNR) staff on each island. User profiles were determined by means of a survey and statistical analysis, and trail characteristics were drawn from field investigations and existing data analyses. The intent of the study was to develop a procedure for DLNR to consider for a comprehensive statewide trail and park analysis for all features within the jurisdiction of DLNR. Through this analysis, a risk management plan could be developed and implemented.

The user profiles were used to determine frequency, preparedness, and demographic information of trail and park users. The study revealed that more than three out of every four trail users were visitors from out of state (78%) and predominantly Caucasian. This resident/visitor ratio was unexpected and indicates that many of the users are unfamiliar with the climate, geology and hazards in Hawai'i, thereby posing a greater threat for the unprepared user. Extensive demographic and behavioral information was gathered from the surveys and compiled into a database for use by DOH and DLNR. The statistical results of that database can be found in Appendix B.

The physical assessment of the trails demonstrated wide variability in the types of potential hazards present on or around trails. Each trail was surveyed with a global positioning system (GPS) unit to identify elements such as rock fall, hazard trees or steep slope. Although this was a descriptive study, the trail analysis made some broad recommendations for further study and regarding trail management.

The most apparent area of improvement concerned signage on the trails, in both quantity and consistency. The survey showed that mileage markers, where available, were the most noticed type of sign. Furthermore, providing information to the user before they arrive at the trail, such as places where a first-time user would

learn about the trail, would increase the user's preparedness. Communication could also improve between trail managers and fire & rescue personnel, so that feedback on the circumstances of an incident may be used toward increasing safety at parks and trails in the state.

As the study team was composed on non-experts in this field, the comments made were mostly passed on from specialists and from the trail users themselves. In general, the report served as a "first cut" to confirm notions of which features are high use areas and where users are inadequately prepared. The report culminates with a self-critique of the process used in the analysis. The intent of the project was for this report and its observations to serve in assisting the team designing a program for a comprehensive study. Recommended improvements to the survey and overall process are provided in the *Insights and Lessons Learned* section of the report.

Introduction

The State of Hawaii Department of Land & Natural Resources (DLNR) manages approximately 1 million acres of land. This land can b divided into roughly three categories: those where the public is actively invited to recreate (e.g. state parks), those where the public is not actively invited but where it is known that the public utilizes the land (e.g. forestry area reserves, unencumbered state land), and those where the public does not enter (e.g. inaccessible watershed areas).

Due to the realization for the need to inventory and assess the risks inherent on DLNR properties and provide mitigative efforts to reduce these risks, DLNR initiated a program that would pursue the identification, assessment and reduction of risk from natural hazards. Such a program would assist in increasing public safety, while forestalling the need for regulation, reducing the exposure to future liability claims, reducing uncertainties, and increasing effective use of limited funds.

One of the challenges that DLNR faces is the balance between reducing the risk and allowing the visitor or resident alike to experience the true natural beauty of undeveloped open lands. Outdoor, open lands pose inherent risks that can never be fully prevented. The key is can the risk be assessed and can the user be informed, to thereby reduce, but not eliminate, the risk. Even the best program will not eliminate risk or injury on DLNR lands.

An internal DLNR Risk Assessment Working Group (RAWG) was convened, comprised of the Deputy Director of the Commission on Water Resource Management, the Assistant Administrator of the Division of State Parks, the State Geologist, and the Trail and Access Program Manager. The RAWG hosted an Environmental Risk Assessment Training Workshop on May 23-25, 2000 for state and county personnel involved in managing public natural resources. This Workshop brought together experts from the U.S. Forest Service, with expertise in hazard trees, signs, trail programs, GIS mapping, and large-scale public resource management. The Workshop also provided an opportunity for DLNR staff to discuss the challenges facing each island.

In attendance at this workshop were University of Hawaii graduate students enrolled in PLAN 751 (Planning Practicum). This is a required course for a Masters degree in Urban and Regional Planning. The intent of the course is for a group of students, usually in their second year of study, to work with an actual client in the community on a planning project that can be completed during the semester. It serves as a real-time exercise in project management, budgeting, scheduling, execution and report composition. Funding to cover project expenses must also be acquired. The students collaborated with the Na Ala Hele Program in the Division of Forestry and Wildlife to define the project, and the Department of Health provided funding from Tobacco Settlement Funds through their Recreation Promotion Program. Five second-year students in the Department of Urban and Regional Planning assumed this project to fulfil the Practicum course requirement. Initial scoping for the project began in May of 2000.

The purpose of this project is to provide information to enable the Department of Land and Natural Resources to shape a risk management program for the management of public lands. An additional purpose is to provide information to the Department of Health on the characteristics of Hawaii residents who hike to be used for future long-range planning efforts. Specifically, this report presents information on the characteristics of the users on Category I lands, collected from a sample of State Parks and Division of Forestry and Wildlife, Na Ala Hele trails on the four major islands. This project also provides an inventory of the physical conditions of the state recreational features where users were surveyed.

Risk & Risk Management Principles

The Chinese word for risk "wei-ji" combines the characters meaning 'opportunity' and 'danger,' recognizing the dual nature of our environment (Smith, 1992). Natural hazards are ever-present, and in some circumstances, are an inescapable part of life (Smith, 1992). The spectrum of human response to natural hazards ranges from free will of public users having the ability to put themselves at risk, to closure of the attraction by the managing entity. Few would want all parks closed because of the risk of harm, yet at the same time, certain potential dangers must be acknowledged and addressed.

As the owner and manager of land on which the public is actively invited to recreate, the State of Hawaii Department of Land and Natural Resources has an obligation to promote public safety and a duty to warn. Whether this duty has been met depends upon many circumstances. However, reasonable care may include the following:

- keeping the premises in safe repair
- inspecting the premises to discover hidden hazards
- removing hazards or warning of their presence
- anticipating foreseeable uses and activities by users and taking reasonable precautions to protect users from foreseeable dangers
- conducting operations on the premises with reasonable care for the safety of the user.

(Peterson & Hronek, 1992).

The development of a risk management program can be used as a means to increase safety while demonstrating the exercise of reasonable care. The fundamental purpose for risk management is to prevent risks from occurring, or reduce exposure to hazard, and may include conducting analyses for system safety, feature safety, liability and third party assumption of risk. It

encompasses all of the actions taken to affect, mitigate, and control risk. Prior to elaboration on the elements of a risk management program, it will be helpful to define some basic terms.

HAZARDS

A hazard is a potential threat to humans or an undesirable event that may occur (Smith, 1992; Lave, 1986). A falling branch over a well-used trail is a hazard, as well as a particularly slippery trail. As the term is used here, a hazard is defined as a source of danger or adverse consequences.

RISK

Any discussion of risk requires a definition from all parties involved in the planning process. This is not to argue validity, but to provide a reference point to explain our risk paradigms. In the most simplistic terms, risk is the probability of a hazard occurrence (Smith, 1992). It can also be defined as the likelihood per unit time of a hazard developing into an actual adverse effect causing loss, death, injury or illness to people (Okrent, 1986). The concept can be expressed symbolically as

RISK = HAZARDS/SAFEGUARDS

This demonstrates that the risk might be diminished by increasing the safeguards, but may never, in theory, be reduced to zero unless the hazard itself or exposure to that hazard is eliminated. Risk may also be portrayed symbolically as

RISK = UNCERTAINTY + DAMAGE

This expresses risk as a measure of uncertainty as to whether damage will occur and the severity of the adverse effect, if it does occur (Waterstone, 1989).

RISK ANALYSIS

Risk analysis is a policy tool that uses a knowledge base consisting of scientific information to aid in resolving decisions. It is typically defined as including three related elements: risk identification, risk estimation, and risk evaluation. The identification of a risk may target a candidate problem, for instance lack of user preparedness. Risk estimation focuses on the probability of the risk event. Evaluation reviews the social consequences associated with the various magnitudes of risk events. As a concept, risk is typically viewed as being a function of two major factors: the probability that an event will occur and the consequence on the event exposure area (Petak & Anderson, 1982). Factors which may assist in calculating the degree of risk are the nature of the hazard, the exposure potential, the characteristics of the exposed population, the likelihood of occurrence, the magnitude of exposures and consequences, and

public values (Kolluru, 1996). Limitations on the use of risk analysis include inadequate data that can result in misspent resources and costly mistakes to lives and credibility (Rowe, 1989).

RISK ASSESSMENT

Risk assessment goes one step further than risk analysis by judging the importance of the consequences of a risk event. Thus, risk assessment necessarily involves making value judgments. The process may include the quantification of risk consequence levels, the estimation of human judgments about risk, and methodologies to integrate the two to evaluate tradeoffs among alternatives to reduce risk (Zimmerman, 1986).

RISK MANAGEMENT

Where risk assessment is the estimation and evaluation of risk, risk management involves the reduction or control of risk to an acceptable level, whether or not that level can be explicitly set (Rowe, 1989). In reality, these processes are not separable because the uncertainty in one affects the judgments made about the other and vice versa.

An essential part of risk management is determining what is an acceptable risk and deciding who is qualified to make this judgment. Some frameworks for making this determination include

- risk-benefit analysis: allowing a particular population exposure level to a hazard is weighted against the benefits obtained from the existence of the recreational feature
- risk-risk analysis (relative risk analysis): the risk of exposure is compared with other risks commonly encountered in the environment or to the risks of doing without any management program
- risk-cost analysis: the cost of achieving a more stringent standard would be compared with the resultant reduction in risk

A risk management plan is a proactive approach to managing risk. While it is virtually impossible to design a plan comprehensive enough to serve all purposes, there are significant benefits to developing a basic risk management program, including: (Peterson & Hronek, 1992).

- promotion and demonstration of concern for user safety
- assurances that steps are being taken to maximize safety within the bounds of possibility
- demonstration of intent to provide a reasonably safe environment
- reduction in losses and/or injuries
- more effective and efficient use of funds and resources
- increased safety for users

People make decisions and take actions based on their personal perception of risk, rather than on some objectively derived measure of threat. The management of environmental risks requires an understanding that often the major part of the problem will result from a difference between perceived and actual risks. The scientific, engineering and business facts of a situation may have little to do with the concerned public's perception of risks. As a result, most risk management plans seek to increase public awareness to hazards as a major activity of the overall program (Petak & Anderson, 1982).

Many types of recreation include the user's perception of risk as a vital element. Climbing, surfing, scuba diving, and other, sometimes more passive, recreational pursuits have elements of risk that may make the recreation more stimulating. While the risk factor of each activity may be evident, it must also be manageable. Use (or non-use) of the proper equipment is one aspect of the total risk.

Because of the variety of users, risk perception has no single replicable outcome; risk means different things to different people because each person holds a unique view of the environment and of environmental risk. Individuals may have a strong but unjustified sense of immunity to hazards and activities and tend to minimize the probability of bad outcomes (Douglas, 1985). To compound the issue, when risk is recognized, the response to risk is also highly individual (Smith, 1992).

Therefore, gathering information on the users of an area is useful in developing a risk management plan. The advance knowledge of the users about the condition of the park or trail, the safety equipment they bring, the level of experience they have, and the attentiveness to signs are all elements which can provide information on their risk perception. Moreover, reviewing the physical conditions of the park or trail gives context to the responses of the users.

Methodology

TRAIL AND PARK USER CENSUS

The purpose of the trail and park user census was to gather baseline usage data on trails managed by Na Ala Hele and State Parks for general public use. The initial understanding was the need to collect data on park and trail usage, activity levels, and basic demographic information of local residents and visitors using the DLNR features such as hiking trails and state parks.

Based on discussions with DLNR, additional information on users' perception of risk, the users' degree of experience, the users' knowledge of local conditions, the users' source of information, and the users' behavior on a trail was requested for collection. The purpose of this additional information was to gain insight on what ways trail and park users, particularly visitors, may be unprepared for hiking in Hawaii and on what aspects of user behavior can be changed to increase public safety.

During these discussions, the Practicum team also received information from DLNR staff on desired and not-desired elements of a risk assessment program. The need for a workable plan, that recognized the constraints of the Hawaiian environment, was stressed. For example, it was noted that trees and vegetation grow exceedingly quickly in a temperate climate and therefore a tree by tree evaluation might be outdated before it is completed. The need for clear, universal signage was mentioned; however, it was also noted that DLNR staff on the Neighbor Islands need the flexibility to design and replace their own signs so that replacement due to vandalism can occur quickly and without delay. Inappropriate promotion of natural resources was another concern, as was consistency of information sources. It was mentioned that it is difficult to educate hikers properly when many receive their information by word of mouth. Finally, increased communication between DLNR divisions and between islands was identified as a common goal to facilitate risk management.

Trail and park selection for inclusion in the user census was based on recommendations of the DLNR managers on Oahu, Kauai, Maui and Hawaii. Trails on Molokai and Lanai were not currently considered because of the more limited use of trails on these islands and time constraints. Trails were chosen to reflect a diverse group of features and to reflect the priority

information needs of the DLNR managers on each island. High use, some type of destination or attraction, and the presence of hazards were predominant factors in the trail and park selection. The following features were selected for review: Diamond Head State Monument (Oahu), Manoa Falls Trail (Oahu), Maunawili Falls Trail (Oahu), Na Koa (Kahana Valley State Park) (Oahu), Awaawapuhi Trail (Kauai), Kalalau Trail (Na Pali State Park) (Kauai), Keahua Arboretum (Kauai), Pihea Trail (Kauai), Waihee Ridge Trail (Maui), Waikamoi Ridge Trail (Maui), Ainapo Trail (Hawaii), Hamakua Ditch Trail (Hawaii), Kahaualea Trail (Hawaii), and Muliwai Trail (Hawaii). On both Oahu and Kauai, there were several additional strong candidate parks and trails that could not be surveyed because of resource and time limitations. Based on potential continued funding for this type of study, more surveys could be conducted in the future.

Simultaneously, a survey was developed to collect information requested by DLNR while also meeting the data collection goals of the Department of Health. Health promotion questions were created based upon DOH and DLNR consultations with staff. Additional questions were added based on suggestions shared by participants of the Risk Assessment Workshop held in May, 2000.

The draft survey was shared with DLNR personnel for comments and suggestions and then field tested at Manoa Falls Trail and Kuliouou Ridge Trail. After field testing, additional changes were made, including alterations to the survey to allow greater ease of capturing the responses from all individuals in a group and changes to the question order. Additional changes to the survey were made after a final meeting with the Department of Health, including more specific questions on residents' physical activity. A similar, shortened survey was prepared with consultation with State Parks for the high use trails of Diamond Head and Kalalau (copies of survey attached in Appendix A).

A schedule of survey periods was prepared, consisting of 6 3-hour periods for each trail. A team of four traveled to each Neighbor Island twice, to conduct surveys on Friday, Saturday, and Sunday. By dividing into teams of two, each trail was surveyed three times over the course of a weekend. Due to unexpected complications and time limitations, however, four trails were surveyed only five times total and one trail [Ainapo] was surveyed twice (See summary on page 11). On Oahu, the survey periods were scheduled to include at least two weekday periods and remaining surveys were scheduled as interviewer schedules permitted. Person hours spent conducting the surveys totaled 467 hours.

Volunteer assistance, recruited from the UH Planning Department and other interested students, was utilized for both Neighbor Island and Oahu data collection. Volunteers were trained before each survey session and a survey procedure and method was reviewed prior to each survey session and attached to the survey clipboard for reference during interviews (contained in Appendix A). Each survey group had one Practicum member as the team leader to ensure data collection consistency.

Data was gathered from trail and park users on Neighbor Islands by interview teams of two people, stationed at locations determined most appropriate through consultation with DLNR managers and through observation of hiker behavior.

Trail Survey Periods

Trail	Survey #1	Survey #2	Survey #3	Survey #4	Survey #5	Survey #6
Diamond Head,	8/27 (sun)	9/16 (sun)	9/30 (sat)	10/15 (wed)	11/2 (th)	11/12 (sun)
Oahu	9:45-12:45	9-12	6-9	6-9	2-5	2-5
Manoa Falls,	9/2 (sat)	9/30 (sat)	10/13 (fri)	11/2 (th)	11/5 (sun)	11/5 (sun)
Oahu	9-12	2-5	10-1	1:30-4:30	9-12	12-3
Maunawili Falls,	9/17 (sun)	9/29 (fri)	9/30 (sat)	10/15 (sun)	10/26 (th)	11/5 (sun)
Oahu	10:30-1:30	1:30-4:30	10:20-1:20	9-12	2:30-5:30	8:45-11:45
Nakoa,	9/2 (sat)	9/24 (sun)	9/24 (sun)	10/13 (fri)	10/13 (fri)	10/15 (sun)
Oahu	12:30-2:30	11-2	2-5	10-1	1-4	9-12
Awaawapuhi,	9/23 (sat)	9/23 (sat)	10/13 (fri)	10/14 (sat)	10/14 (sat)	
Kauai	11-2	2-5	2-5	8:45-11:45	1:40-4:40	
Kalalau,	9/22 (fri)	9/23 (sat)	9/23 (sat)	10/13 (fri)	10/14 (sat)	10/14 (sat)
Kauai	10:30 - 1:30	10:10 - 1:10	1:45-4:45	1:20-4:20	8:25-11:25	11:25-2:25
Keahua,	9/22 (fri)	9/24 (sun)	10/13 (fri)	10/15 (sun)	10/15 (sun)	
Kauai	3-5:30	10-2	8:30-11:30	8-11	11-2	
Pihea,	9/22 (fri)	9/24 (sun)	9/24 (sun)	10/13 (fri)	10/15 (sun)	10/15 (sun)
Kauai	1-4	9:30-12:30	2-5	10-1	8:15-11:15	11:15-2:15
Ainapo,	10/21 (sat)	10/21 (sat)				
Hawaii	8:30-11:30	11:30-1:30				
Hamakua Ditch	9/29 (fri)	9/30 (sat)	9/30 (sat)	10/20 (fri)	10/21 (sat)	10/21 (sat)
Hawaii	2-5	10-1	1-4	8:30-11:30	10-1	1-4
Kahaualea,	9/29 (fri)	9/29 (fri)	9/30 (sat)	10/22 (sun)	10/22 (sun)	
Hawaii	11-2	2-5	9:30-12:30	10-1	1-4	
Muliwai,	9/29 (fri)	10/1 (sun)	10/1 (sun)	10/20 (fri)	10/22 (sun)	10/22 (sun)
Hawaii	10-1	10-1	1-4	1-4	11-2	2-5
Waihee,	9/9 (sat)	9/9 (sat)	10/6 (fri)	10/7 (sat)	10/7 (sat)	
Maui	9-12	12:45 - 3:45	3:30-6:30	8-11	11-2	
Waikamoi,	9/8 (fri)	9/10 (sun)	10/6 (fri)	10/6 (fri)	10/7 (sat)	10/7 (sat)
Maui	12:45 - 3:45	8:45-11:45	10-1	1:30 - 4:30	9:30-12:30	12:30 - 3:30

Members of the interview team approached groups as they exited the trail. Responses from every individual in the group were collected, however adults sometimes responded for children in their group. For low use trails, every group was interviewed, and for high use trails, every next group was interviewed, so that when one survey was complete, the interviewer then approached the next group to exit the trail. Commercial tours were not interviewed.

Data was stored in a Microsoft Access database and analyzed utilizing SAS (Statistical Analysis System) (database codebook attached in Appendix A).

PHYSICAL ASSESSMENT

An inventory of the physical conditions of these select recreational features provides the study with baselines of both the identification of the potential trail hazards as well as the evaluation of trail user preparedness. All observations, judgments, and recommendations contained in this report are for exploratory purposes only and should not substitute for the seasoned opinion and experience DLNR staff and expert consultants. Moreover, potential hazards are identified without assessment of the degree of harm or consideration of available resources for mitigation.

For future studies, it may be more helpful to policy makers and to the general public to conduct an analysis that is more qualitative and descriptive in nature than to make an attempt to quantify the numerous factors contributing to potential risk. This would take time and resources beyond the scope of this pilot assessment. In addition, expert consultation from a myriad of disciplines would have to be employed in a "Delphi" process, where a number of rounds of subjective evaluations of various data types would serve as the basis for hazard quantification. This approach is strongly recommended for a future comprehensive risk management program.

This particular portion of this project was an exercise to locate, identify, document, evaluate, and make suggestions regarding alternative actions to address the hazards at select state features. The primary potential environmental hazards considered for the project inventory were landslides (including rockfall), trail surfaces, flash flooding, and trees. A variety of factors contribute to each of these hazards. For instance, landslides are directly influenced by slope, soil composition, vegetation type and cover, rainfall, and other indirect elements. As mentioned in Burby (1998), it would be impossible to accurately quantify each of these variables and weigh them appropriately with regards to each other. However, qualitative assessments can be initiated and educated judgments by experts in the field would be the most accurate means of

determining the status of hazards on public lands. Part of an ongoing hazard management plan would be to precisely document the conditions surrounding, for example, a landslide event in the vicinity of a park or trail. This could only be effectively accomplished with improved monitoring of conditions such as climate as well as human-influenced and naturally occurring erosion.

Field observations were recorded using Global Positioning Systems (GPS) technology, specifically with a 1996 Magellan ProMark IV. The unit marked the three dimensional location of the observed potential hazard as well as the category, severity of consequence, and the estimated probability that the hazard would occur. The instances were then tallied and used as a descriptive means of establishing qualitative risk.

For consistency purposes, one student researcher in the Practicum group was designated to conduct physical assessments on all 14 trails, concurrent to the social data collection. Observation times varied among the surveyed trails depending upon total distance, difficulties in traversing the trail, and satellite signal reception capability. The latter challenge was due to the amount of cloud cover and precipitation as well as the thickness of the forest canopy. Detailed descriptions of the hazard character and context were noted and referenced in conjunction to the individual data files created specific to that observation. For example, a potentially hazardous tree was described according to its specie, size/age, its relative aspect to the trail (target potential), the severity of the hazard, and practical mitigation/abatement options specific to that observation.

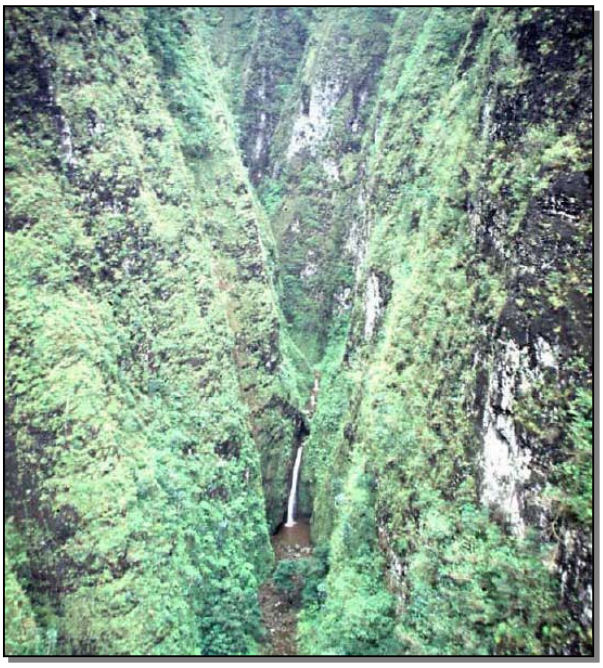
The results of the physical assessment of trails and parks varied greatly from feature to feature. Some trails had no landslide hazards whatsoever, yet possessed a great deal of potential tree hazards. These results demonstrated the need for a flexible, yet comprehensive, risk management plan that could address the dangers that exist on particular features. The results for individual trails are represented in the individual trail summaries as well as in Appendix E.

NATURAL HAZARD OVERVIEW

Natural hazards are all around us and may occur at any time. The volatile climate of the tropics and varied geography of Hawaii increase the uncertainty and intensity of these hazards. Large-scale hazards such as hurricanes, tsunamis, volcanic eruptions, and earthquakes can be catastrophic events, but the more localized hazards can be equally harmful. As hurricanes, for instance, are broad-region, well-monitored events, a flash flood occurs without warning and is very specific to the affected area. The ignorance of hazard and the affiliated lack of preparedness of people exposing themselves to a flash flood, or any other localized hazard, is where the true hazard lies. These events have happened for millennia and will continue to take place despite management efforts to contain them. What can change is how aware and prepared people are to these hazards so that the severity of the consequences may be reduced. As part of this study, several localized hazards were identified and evaluated. These hazards include landslides, flash floods, hazardous trees, hazards associated with climate and topography, and trail surface. There are other hazards, such as infections or animal attacks for instance, that have a more limited effect on users, but may be addressed in a comprehensive study in the future.

LANDSLIDES

Landslide event probability begins with the height and steepness of the slope, whether it is a ridge or valley trail. The greater the shear of a cliff, the narrower the zone of impact would be.



However, in narrow valleys such as Sacred Falls, a high vertical drop still renders the entire valley exposed because of the ricochet effect. Lesser grades usually cause more lateral movement, so a trail that is a short distance from the cliff base would still be at risk of rockfall. Soil type also has an effect on landslide possibility, with regards to their response to moisture content and adhesion qualities. Naturally, composite substrates of rock and soil or a predominance of solid rock has considerably more damage and injury potential than a slide containing only soils, so the level of heterogeneity also has an effect on the consequence of a landslide incident (Bauer, 2000).

Overall mean precipitation is the major cause of slope failure (Baum and Jipson, 1999). Slow, gradual erosion has a long term effect whereas a short-term, high volume deluge also has obvious effects as evidenced in the New Year's storm of 1987 in east Oahu (Division of Water and Land Development, 1988). There is a correlation between rainfall, streamflow and talus at the base of a given cliff. Reconnaissance of rockfall material from previous events at Sacred Falls and Maakua Gulch revealed that the rockfall of the Mother's Day 1999 event was miniscule in comparison to the geologic record, with a volume of less than 50 m^3. In absence of recorded landslide data, this evidence can be used to approximate the frequency of rockfalls in the area, in conjunction with visible scars on the valley walls (Baum and Jipson, 1999).

Vegetation cover and type is yet another independent variable to be considered. Studies have demonstrated the effect of flora on slope stability and determined that the surface root systems of native species tend to mat down and reduce landslide frequency. On the other hand, alien species characteristically have tap-rooting systems that are more intrusive and tend to disrupt slope stability (Scott, 1969). One example is the impact of miconia in Tahiti, an alien species which has been responsible for some landslide events. Seismicity is also a factor contributing to slope failure (Crozier, 1986), but not all islands possess the same seismic rating. For example, Kauai is a considerable distance from the geologically active zones of the Big Island. Hence, seismic activity is not considered a major factor on islands on the western half of the island chain.

Where slope failure is a concern along a trail, all of these factors are taken into account. Rather than a quantitative means for documenting the landslide potential, a descriptive analysis of these factors will serve to demonstrate the relative potential for slope failure.

HAZARD TREES

The giant trees that may be seen over a given trail also pose a potential hazard. When trees reach their mature size, they tend to deteriorate and eventually lose their limbs, and in some cases, fall down altogether. Many of the trees used for reforestation of the higher watershed regions of the Hawaiian Islands are non-native, quick-growing varieties. Eucalyptus and albizia are two introduced species that were extensively planted

about seventy years ago, and are now nearing the end of their lifespans. These trees are known to lose branches due to the heavy rains and strong winds characteristic of the islands. However, some of the larger indigenous and native species may also threaten the safety of trail users. Koa (Acacia koa) is a prized native hardwood that also has an optimal lifespan that, when exceeded, may result in growth beyond its supportable weight.

In an attempt to approximate the risk of hazard trees observed in the area, several criteria were developed for the purposes of this project. First, a hazard tree was identified by its aspect to the target, that is, is it leaning toward or over the trail. Unless there was a spur trail leading up to a potentially hazardous tree beyond the falling reach of the main trail, the hazard tree was not documented. The specie of the tree was noted, as the constitution of some tree varieties are more apt to breakage than others. Then factors such as the girth of the bough or limb was considered and rated, as well as the nature of the break, the degree of tree rot, and the health in general of the tree in a Hazard Tree (HT) factor from 1 to 5.

HT 1 – Highest priority for mitigation, most likely requiring immediate removal or trimming.
HT 2 – Tree poses a serious threat of falling over the trail in the near future, possesses recognizable ailments and should be reviewed for mitigation.
HT 3 – Usually smaller, high branches affected by strong winds, but also large, shorter trees in average health, still with a direct falling line to the trail.
HT 4 – A large tree in relatively satisfactory health, or smaller trees directly above trail. Questionable as to whether the tree will fall onto the trail or not.
HT 5 – Small trees are present but pose no immediate threat of harm.

This ranking is a hierarchy of response, with an HT 1 being immediate removal and HT 5 a situation where signage is the only reasonable means to mitigate a low probability incident from occurring. A basic tree management program for each trail would be the most appropriate means for addressing the uncertainty involved with falling branches and trees. This would include a comprehensive inventory of all trees along a trail, their species, their relative risk ranking, and periodic review of their condition.

FLASH FLOODING

Flash flooding is a hazard related to characteristics specific to a certain area. The presence of perennial streams indicates a high annual rainfall with consistent distribution in the specific region. Any sudden aberration from this normal precipitation and a narrow stream course may

soon bear several times its usual volume, creating a quick-moving, potentially fatal hazard if people are present. Most flash floods cause the most harm downstream where it may not even be raining at the time of the flood, catching hikers off-guard. Although hikers may be directly exposed to a flash flood for a very short time, if the trail requires passing back over a recently swollen river, the hikers may be prevented from completing the course. This may prompt a desperate user to attempt to cross a rushing stream and risk being swept downstream and drowning. For the purposes of this study, if a stream course is present on the trail, whether it be flowing or not it is considered a potential flash flood zone.

HUMAN ERROR

Wandering off a trail may happen either intentionally or unintentionally. Hikers may seek an improved vista for sightseeing or for a photographic opportunity. Some trails like the Nakoa Loop in Kahana Valley, only cover a small area and do not explore the back of the valley, which prompts some more adventurous hikers to venture off on spur trails blazed by hunters, who are more familiar with the valley and seldom use a particular marked trail. Additional visitors using trails means that there are more people unfamiliar with that feature and with the local conditions.

A hiker may not know that he or she has left the trail due to poor markings or the presence of spur trails with comparable tread-ware to the main trail, or the user may simply not be paying attention. Hunters and hikers alike use colored ribbons to find their way back to familiar territory, but often leave the ribbons behind, which may be mistaken by the next trail user as the official trail.

The rule of thumb for many hikers in the continental United States is to find a stream course and follow it to where it will inevitably find a road. In Hawaii with the quick changes in elevation, numerous waterfalls and dense vegetation, following a stream is not be the wisest means of regaining one's bearings and is actively discouraged by DLNR managers.

CLIMATE & TOPOGRAPHY

This is a broad category of hazards that includes the effect of elevation gain on users, exposure to solar radiation, and the risk of fire. Some of the trails in the Na Ala Hele system, such as the Ainapo Trail on the Big Island, wind up to the very summit of 13,679 ft. Mauna Loa, exposing the hiker to freezing temperatures and effects related to altitude. None of these extreme conditions were surveyed as part of this study. Exposure to solar radiation is related to the amount of tree cover over a trail. If the trail is particularly long, attempted in the middle of a cloudless day and features little forest canopy, then the user runs an increased risk of heat

stroke and dehydration. This is amplified if the trail has variable elevation. The risk of fire is related to climate, as only drought-tolerant species can survive, which are usually quite flammable. At Diamond Head State Park, for example, if a lit cigarette ignites the dry understory at the bottom of the trail, those who have completed most of the trek may be stranded or directly harmed by the blaze.

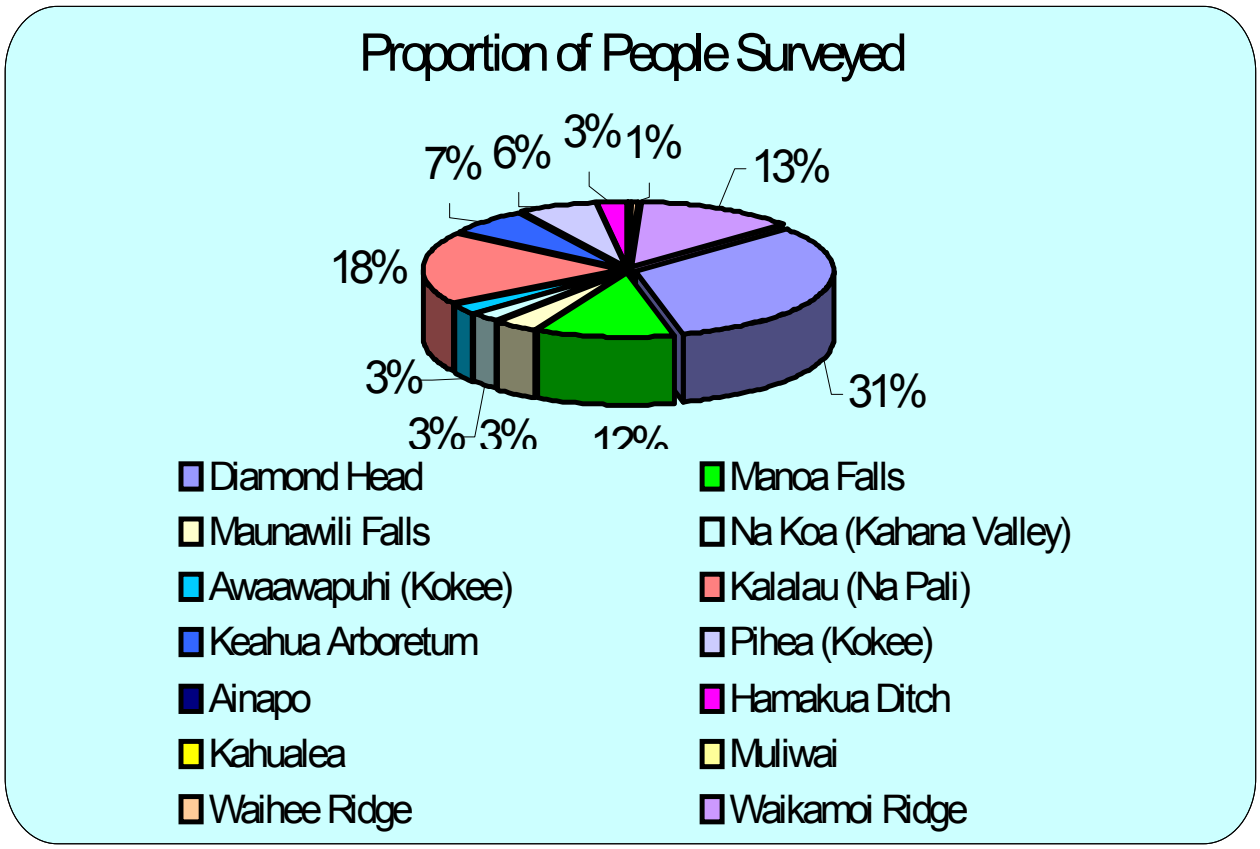
Trail Summaries
State of Hawaii

The State managed trails system in Hawaii is one of the most geographically diverse systems in the United States. Hawaii has a high concentration of trails in relatively close proximity to one another. Along with the privileges of access to public land come responsibilities on the part of both the managing entity and the public. On the part of the state, this means maintaining trails for safe travel while preserving the natural ecosystems or cultural resources. In places where the safety of trail users may be reduced, it is the responsibility of the state to inform trail users of the risks they may potentially encounter. Trail users are responsible for their own awareness and level of preparedness. They are entrusted to enjoy the most intimate places in the islands with as little negative impact as possible.

This portion of the report introduces the results of the user survey and also of the physical assessment. The survey determined how prepared and aware users actually were, and the physical assessment noted what hazards they should be conscious of. This section first gives overview information that is significant to the entire state. This information is then broken down by island and then more specifically by trail. A complete summary of all the data collected can be found in Appendix B.

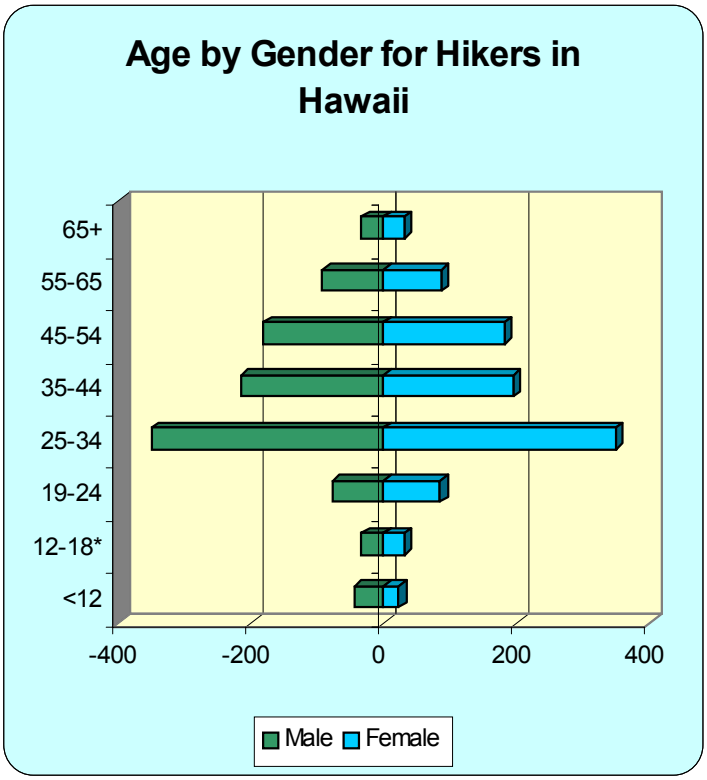
STATEWIDE STATISTICAL PROFILES

The survey team analyzed fourteen trails in the State Parks and Na Ala Hele Trails system. On each of these trails the survey team spent six, three-hour periods surveying trail users. Four of the survey periods were completed on weekends, and two were undertaken on weekdays. Each trail was also analyzed for significant physical conditions with a GPS unit.



Of the 14 features surveyed, the highest uses in the state occurred on Diamond Head, Oahu, Kalalau Trail, Kauai, Waikamoi Ridge Trail, Maui, and Manoa Falls, Oahu. At both Diamond Head and Kalalau, more than half of the users were not interviewed due to the limited number of interviewers and the high use of these areas. The trails on the Big Island were very low use the times they were surveyed. There is some indication that these trails get more use than was observed by the survey team, however even if the number of hikers doubled, most of them would still be considered low use trails (having less that 10 people/day).

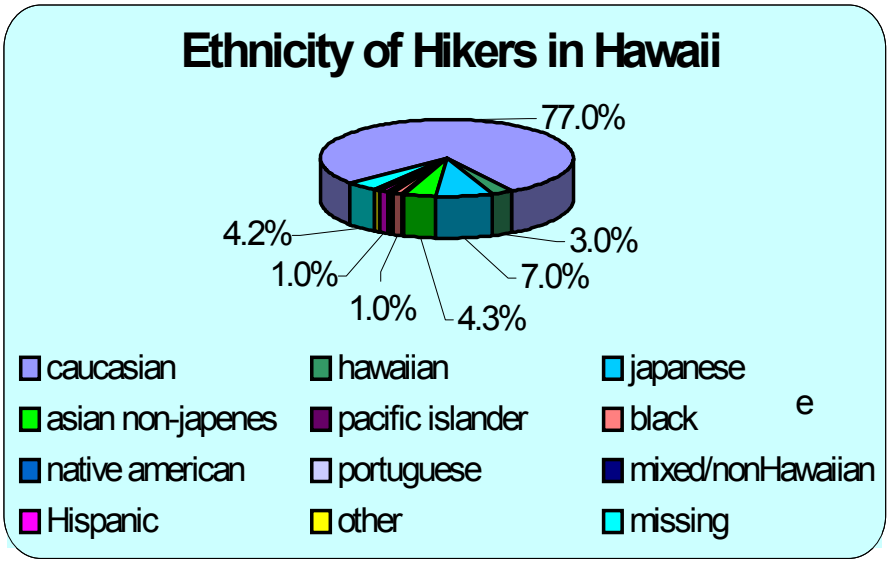
Demographically, all of the high-use trails seemed to have the same types of users (tourists between the age of 25 -54 and Caucasian) and all of the low use trails had similar demographic characteristics (predominantly local hikers of all ages and mixed ethnicities)



The chart at the right is an age-cohort graph that indicates the number of hikers by age and gender. From the chart we can see that there are more men hiking but only by a little. The largest group of hikers is the 25-34 age category.

On a couple of trails (Maunawili Falls and Nakoa) a large number of young adults between the ages of 12 and 24 were observed hiking the trail. The average age of hikers on Diamond Head is a little older than the statewide average which falls within the 25-34 category.

The majority of hikers surveyed were Caucasian. On some trails, such as Diamond Head, many people were not surveyed during some survey periods because of a language barrier. It is likely that more Japanese hikers would have been surveyed if more Japanese-speaking survey team members were used during the survey periods. For the most part the chart at the left illustrates the ethnic breakdown of hikers on the trails that were surveyed in the State of Hawaii.



The most interesting statistic in the trails that were surveyed was that 78% of hikers were visitors to the State of Hawaii (even if Diamond Head is removed from the analysis, 75% of hikers were from out of state). DLNR suspected that in high -use trails, there were a large number of tourists. However, the survey also proved that an overwhelming majority of hikers are not familiar with Hawaii's natural environment, weather patterns and trails system. As might be expected, this often has an effect on the level of preparedness of hikers. For example, there were really only two trails, Waikamoi Ridge Trail and the Keahua Arboretum, where users could get away with not having water and other supplies with them. Those hikers would account for 20% of those surveyed. Yet, 45% of those surveyed did not have water with them (see Appendix B). Based on hikers' comments, many of the tourists expected more facilities at the trails such as comfort stations and drinking fountains.

The first survey for this project was conducted on August 27, 2000 and the final survey was completed on November 12, 2000. Considering the high number of tourists on the trails, the total number of hikers might change dramatically depending on the season in which the surveys are taken. These surveys were conducted in what is generally thought to be the low season in terms of tourism. It is possible if the surveying was done in the summer, the numbers would be very different. Survey periods started anywhere from 5:45 AM and generally were completed by dusk, around 6 PM.

The majority of trail users indicated they were hiking to see the attractions and views. Considering that most of the hikers were visiting the Hawaiian Islands, this seemed natural that people would hike as a site-seeing outing. Many locals indicated that they were hiking for exercise or to experience nature. A few people were practicing their native Hawaiian cultural heritage.

Island of Oahu

The Practicum group met with Aaron Lowe, Na Ala Hele Oahu Trail Manager, and Dan Quinn, the Assistant Administrator of the Division of State Parks, on June 23rd , 2000, to discuss trails and parks on Oahu. In this meeting, general hazards mentioned included trees and flashfloods as "unseen" risks. Vegetation growth can impact views and hide drop offs. Due to Oahu's high visitation, the question of accommodating unprepared users was also discussed.

The following trails were proposed for consideration for survey purposes:

- Diamond Head – as an extremely high use trail (1.3 million/year), where the users have a significant impact on the trail and environment, in terms of erosion and litter; also has a historical military aspect with fortification bunkers
- Nakoa (Kahana Valley) – a relatively low use trail, but the location for several reports of lost hikers; signage has been added to address this problem
- Manoa Falls – a high use trail, used by those who want to see a waterfall and those who want to wade under the falls; potential for rockfall, flashflood, and leptospirosis; concern about attempts to access the higher pools without a trail along the steep cliff; has signage to address hazards
- Maunawili Falls – a moderate use trail, used by many who wish to go swimming under the falls; do have attempts to access the higher pools and potential for slip and fall; leptospirosis
- Pali Lookout – an extremely high use path, paved to a lookout; wind and dust are primary hazards
- Makapuu – a moderate use trail; plan to keep in natural state
- Tantalus Mauka system – all trails in system of moderate to high use; easily accessible by Waikiki and urban Honolulu
- Maunawili Demonstration – high use trail along the first two miles
- Wiliwilinui, Kuliouou, & Hawaii Loa Ridge – moderate use trails; ridge trails with steep sections; potential erosion; easily accessible by Waikiki and urban Honolulu
- Peacock Flats – camping area; aging trees; user conflicts between mountain bikers and four wheel drive

The trails selected were Diamond Head, Manoa Falls, Maunawili Falls, and Na Koa (Kahana Valley State Park). These areas vary widely in terms of use, environment, and potential hazards. Diamond Head State Monument and Manoa Falls are both close to Waikiki and

have a significantly higher usage than Maunawili Falls and Na Koa, both located on the Windward side of Oahu. It is almost impossible to come to Oahu and not become aware of Diamond Head; whereas, Na Koa and Maunawili Falls (a relatively new trail) are less publicized. Diamond Head is an improved trail, with pavement for approximately one-quarter mile, handrails and stairs. Manoa Falls, Maunawili Falls, and Na Koa are maintained in a more natural state.

These differences are reflected in the data received by the users of each trail. For example, only 16% of the users at Diamond Head were residents, in comparison to a 82% resident use rate at Maunawili Falls. Differences will be seen in more detail in the next section discussing the specific characteristics of each trail.

There are potential trends that can be seen among the trails on Oahu:

- People are most likely to hike in pairs (with the exception of Na Koa, where they are most likely to hike in threes)
- Between 20% -25% of the groups were composed of single hikers (except Na Koa, where 12% of the groups were composed of single hikers)
- The majority of users heard about the trail by word of mouth
- More than 50% of the users on each trail wore running shoes
- More than half the users (Diamond Head excluded) notified someone not with them that they intended to go hiking
- 13% - 17% of the users of each trail had previously gotten lost while hiking
- Less than 12% of the users admitted to leaving the marked path
- Over 90% of the users recalled the existence of signage on the trail, yet what they recalled seeing varied widely

Diamond Head Trail, Oahu

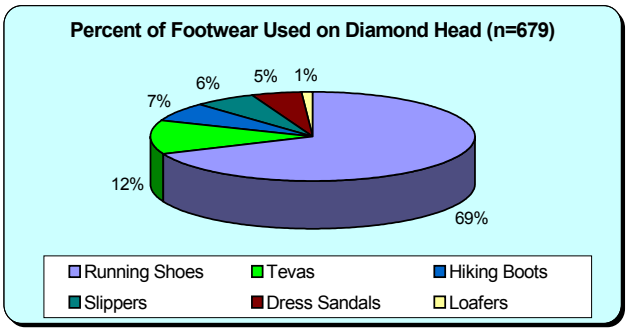
An extremely high-use trail, the Diamond Head trail is a steep 1.4 mile hike inside Diamond Head Crater which leads visitors to the Leahi Summit. The trail is dry and the crater's interior can be extremely hot due to a lack of wind. The trail begins as a paved pathway and continues as an improved dirt path with a gradual incline and over 250 stairs until reaching the 760 foot summit. For those that reach the top, the summit affords a 360-degree panoramic view of southern Oahu. There is currently a charge of $1 to enter the State Park. Between 1500 and 2500 people visit the park daily and it is estimated that 1.3 million people visit the landmark every year.

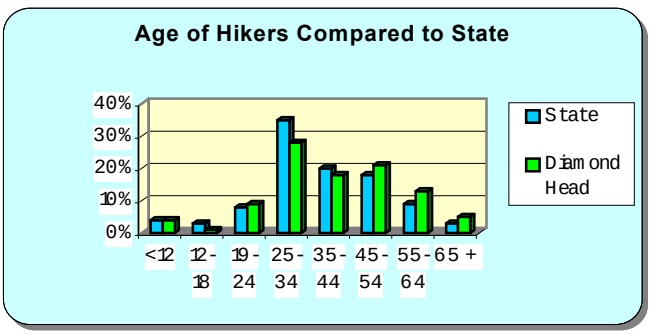
Hazards

Heat, sun exposure	Erosion and falling rocks
Unstable footing	Risk of Fire
Strenuous climb	Darkness in tunnels and bunkers

Diamond Head User Profile

Diamond Head is visited primarily by tourists (85% non-local hikers). Some locals hike the trail for exercise and meditation in the mornings. A large number of hikers are Japanese tourists. These groups often could not be surveyed because of a language barrier and/or a refusal to participate in the survey. Therefore, the data for this trail does not necessarily paint a representative picture of trail users. (Example: at least 5 people were observed wearing heels on the trail but none could be surveyed.) The users that were surveyed, on average, were older than those surveyed on other trails (39% over 45 years old).

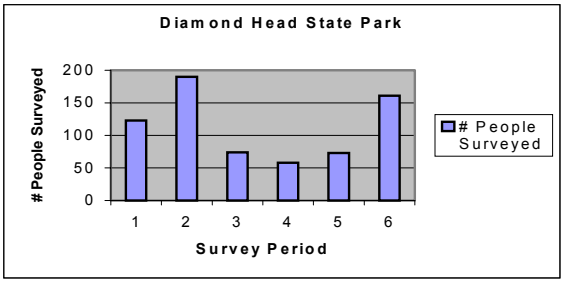




Social Profile of Trail and Trail Users

Survey Period Synopsis: The survey team set up about a quarter mile into the trail, where the pavement ends and the improved dirt path begins. This location was chosen as the majority of people passing this point intended to hike to the summit. During each survey period (with the exception of the early morning survey period), less than half of those passing by were surveyed. This was due to the sheer numbers of people hiking. The variance in the total number surveyed is attributed to the numbers of surveyors. There were between two and four interviewers at each survey period, and the second survey period included 2 Japanese speaking interviewers. The majority of people were hiking "because it was Diamond Head," one of the "must-do" activities when visiting Oahu. The highest use occurs between 10:00AM and 2:00PM, when more than 250 people enter the trail each hour.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Sunday	9:45-12:45pm	123
2	Saturday	9:00-12:00pm	190
3	Saturday	6:00-9:00am	74
4	Wednesday	6:00-9:00am	58
5	Thursday	2:00-5:00pm	73
6	Sunday	2:00-5:00pm	161



Trail Conditions: Several signs warn hikers of potential hazards, however many people fail to take time to read them. Most information about the trail is located at or near the information booth at the parking area. The trail is somewhat slippery due to the crumbling rock surface. Near the summit, hikers are led through a dark tunnel, up a spiral staircase and out to old bunkers perched on the crater rim. Many hikers commented that the lack of lighting on the spiral staircase was unnerving. Several hikers thought that squeezing through the bunker at the summit could be difficult for less nimble hikers to navigate. Many people commented that they wished they had brought more water and a flashlight. In fact, on the way down, some of those that did bring flashlights, passed their flashlights to hikers headed up into the tunnel.

Physical Profile of Diamond Head Trail

Most of the hazards on this trail are associated with the intensity of its use. The beginning of this trail deceivingly gives the impression that this is a well-developed trail, as there is a wide paved sidewalk for the first quarter of a mile. After this point, the trail surface is eroded basalt originally routed by the US Army when they occupied the crater. The army also constructed the tunnel and concrete bunker network along Leahi Ridge, which provides the route for the last half of the trail. The destination is an eroded bunker at the peak of Leahi which affords dramatic views of Waikiki, Honolulu, Koko Head, and the leeward side of the Koolau Mountain range. The mean annual rainfall is less than 20 inches. The vegetation in the crater consists of kiawe (*Prosopis pallida*) and haole koa (*Leucaena leucocephala*), with an understory of fingergrass. Thus, there is no protective canopy. There are no streams along the trail. There are five potential hazards that exist on the Diamond Head Crater Trail: trip and fall, exposure/fatigue, brush fire, landslide/rockfall, and infrastructure-related issues.

Trail Surface: The trail surface beyond the paved sidewalk is extremely eroded and uneven, creating a potential traction hazard. This is intensified by the fact that users may experience fatigue due to exposure to the sun. The route is lined with handrails in its entirety to assist the mass of people to reach the summit. The uneven path may cause tripping. This hazard increases if the user leaves the path and attempts to climb the steep crater walls. The trail surface at the tunnels and beyond are predominantly paved. Aging military bunkers await the user at the destination.

Climate & Topography: Because of the lack of shade and the steep grade for most of the climb, fatigue is a serious concern. Hikers often expect an easy climb with a few exciting dark tunnels and then reach a great view. This is evident in the choice of dress, selection of footwear (such as loafers and sandals), and provisions. The average age of the Diamond Head user is higher than at other trails, which makes these choices even more critical to the safety of the trek. There is no water available to users beyond the trail head. Due to the low annual rainfall, dry vegetation, and non-hiker smokers, there is a considerable fire hazard threat.

Landslide/Rockfall: The loose, crumbly soils in the crater combined with the steepness of the crater walls provides ideal conditions for erosion, either in the form of incremental rockfall or mass movements of substrate. The fractured rock that composes the crater slopes may gradually lose stability and fall. The fact that there are several switchbacks on a given slope

allow for a falling rock to hit a number of potential targets. The high volume of the trail increases the likelihood of contact with a trail user. Users that ignore posted signs and leave the trail are subjected to increased risk of not only slip and fall, but also inadvertently creating a rockfall that may impact users on the trail below.

Infrastructure: The trail route ventures through two sections of tunnels and one spiral staircase, both without the benefit of lighting. The tunnels and stairs were not designed for mass-movements of people, but for military operations, and have not been modified significantly since army occupation. The pill boxes through which the trail runs are in poor repair and are difficult to negotiate for some users. Pill boxes not on the trail course may tempt more adventurous users to leave the trail and experience greater risk exposure.

Existing Management Practices: There are a considerable number of signs throughout the trail reminding people to not leave the trail, to not smoke, etc. The handrails are helpful to keeping people on their feet. As for the fire hazard, there are access roads to manage a potential blaze, but those users who happen to be caught at the top will have to wait out the fire or wait to be rescued. Improvements to the trail and bunker area are scheduled for January, 2000, and should address many of the infrastructure related issues mentioned above.

Possible Action Steps: There is little that can be done about the fire hazard except to continue to prohibit smoking in the park and have a fire evacuation plan. Exposure and fatigue could be reduced through construction of simple shelters with benches at various points on the trail, and by providing water. Landslides will continue to be a potential threat regardless of removal or reinforcement of hazardous slope areas, and this risk could be communicated through a consolidated signage program at the trailhead and/or at points where the hazard is present.

Manoa Falls Trail, Oahu

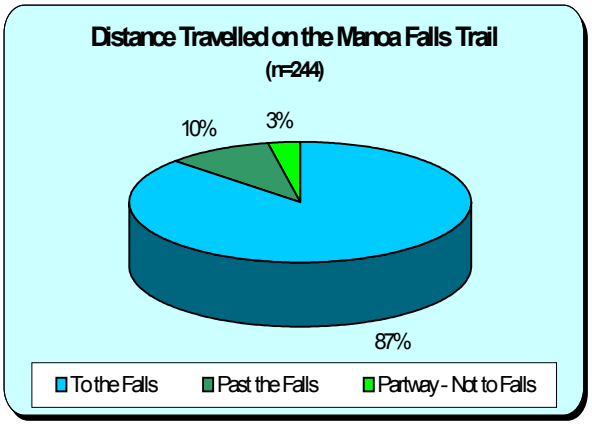
Manoa Falls is a 1.6 mile roundtrip hike to a seventy-foot waterfall. The trail closely follows the Manoa Stream. Sections of the trail surface is gnarled by roots and rocks. The majority of the trail is covered by a dense rainforest canopy. The incredibly humid climate causes the trail to be continuously wet, muddy and buggy. A short distance from Honolulu, Manoa Falls is a very high-use trail (average of 35 people per hour on the weekends and 13 people per hour on weekdays). This can be problematic for this sensitive watershed. The majority of people surveyed (67%) felt this was an easy hike.

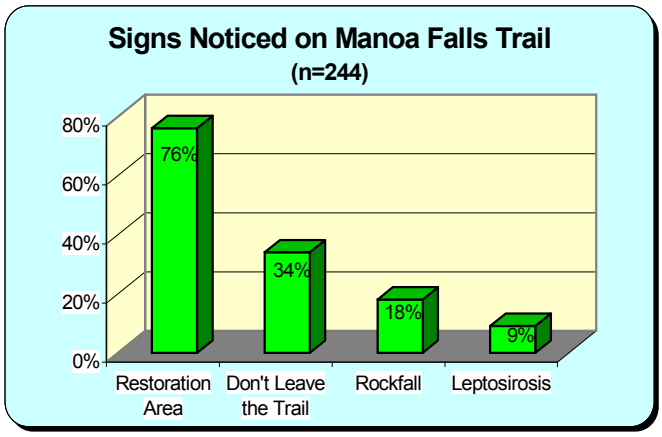
Hazards

Wet weather conditions
Slippery trail, protruding roots and rocks
Leptospirosis
Falling rocks and branches
People

Manoa Falls User Profile

This is a high use trail, visited by both locals and tourists (45% local and 55% non-local). The highest uses occur on weekends when most of the locals are hiking. Many of the non-locals learned about the trail from friends on Oahu. This could be seen by the number of combination groups; it appears many local residents take their visitors hiking at Manoa Falls. Hikers have a wide range of experience levels and learned about the trail from several different sources.

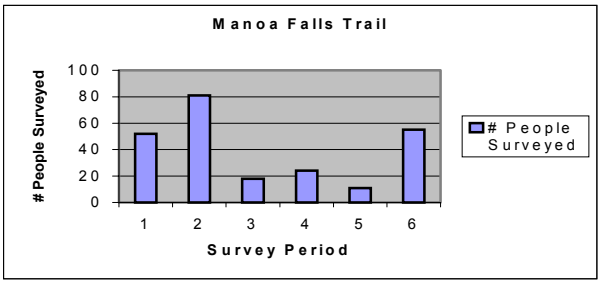




Social Profile of Trail and Trail Users

Survey Period Synopsis: The survey team set-up about 30 ft beyond the trailhead. The preferred location would have been about 250 ft into the trail at a clearing point, however, a commercial operator was consistently set up with a table and water coolers at this spot. Many people complained about the vendor and asked what could be done to remove commercial sales on the trail. Very few locals hike the trail on weekdays, but many use the trail for weekend recreation. Some of the hikers had clearly been swimming somewhere along the hike. On two occasions unlicensed commercial tours were noted taking groups larger than 15 on the trail. Some local residents concurred that commercial tours not be allowed on the weekends when local families are trying to enjoy the trail. Some commercial operators ignore this restriction.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Saturday	9:00-12:00pm	52
2	Saturday	3:00-6:00pm	81
3	Friday	10:00-1:00pm	18
4	Thursday	1:30-4:30pm	24
5	Sunday	7:30-10:30am	11
6	Sunday	10:30-1:30pm	55



Trail Conditions: The trail is signed for hazards, but the signs are in places where few people notice them. Many people remember the restoration area signs. There are no mile markers and no sign that tells a hiker how far it is to the falls. Most of the people who took the bus to the trail said they would appreciate directional signs from the bus stop to the trail. Few people recalled seeing the end of trail sign.

Many people commented that the new steps, provided for erosion mitigation, are more slippery than the trail itself. Several people felt handrails (bamboo) would be helpful and improve stability for hikers at the new steps.

Physical Profile of Manoa Falls Trail

The trail itself is quite wide in many sections due to high use and there is evidence of extensive regular maintenance. Gravel has been added along the entire .8 mile route. There is one minor stream crossing near to the beginning of the trail, which is a tributary to the main Manoa Stream. The rest of the trail is somewhat removed from the stream, although they run parallel to each other. Nearly the entire length of the Manoa Falls Trail is under a high-tree canopy, however the healthy condition of most of the trees render this feature relatively safe. This canopy also protects users from direct exposure to sunlight, which lessens the possibility of fatigue. Due to the high cliffs and soil composition, there is the possibility of rockfall at the trailhead and near to and at the destination. In all, there are four potential primary hazards: rockfall, trail surface, trees and the destination itself; and two secondary but nonetheless critical hazards: spur trails and flash flooding.

Rockfall: The Manoa Falls Trailhead features a universal graphic sign indicating rockfall hazard, which is again posted at the destination, the two locations where the potential hazard may occur. Few users would immediately be aware of a hazard just off the parking lot, yet there is a 25-foot high, 60% grade cliff on the left hand side as one enters the trail. Trail proximity to the hazard diminishes after only a few yards, and there is relatively no potential slope hazard until a few hundred yards before the end of the Manoa Falls Trail. At this point, there is a consistent 60-70% grade cliff with moderate to comprehensive vegetation cover, which aids in preventing rockfall from further upslope. Possibly the greatest danger of rockfall is at the attraction itself, Manoa Falls. The face of the waterfall is composed primarily of solid and fractured rock with little or no soil, which means fewer but more substantial rockfall episodes, as evidenced by the talus at the base of the falls.

Trail Surface: Due to the relatively high annual rainfall in the Koolau Mountains, one can usually expect to experience muddy and slippery conditions along the non-graveled portions of

the trail. At several points, particularly where there is a noticeable change in elevation, trail improvements have been made to alleviate the traction problem as well as prevent further erosion due to high volume and wet conditions. This has only achieved limited success, as users commonly sidestep the boardwalks as they encounter other users and as the boardwalks become slippery when wet. DLNR has also laid limestone gravel along portions of the trail to increase traction and reduce erosion.

Falling Branches: Hazard trees are present at several points along the trail, although nearly the entire trail is under tropical forest canopy. Species observed along the trail include albizia (*Albizia falcataria*), hau (*Hibiscus tiliaceus*), kukui (*Aleurites moluccana*), eucalyptus (*Eucapyltus robusta*) and octopus tree (*Schieffiera actinophylla*). There were 10 potentially hazardous trees observed along the trail, most of which were albizia. There was one unidentified tree growing laterally out and adjacent to the face of the waterfall. This tree was considered a potential hazard although it was in apparent good health due to the fact that its roots are boring into fractured rock, and eventually may loosen and possibly cause a rockfall into the pool area below. Most of the other hazard trees were suffering from trunk rot and featured an aspect toward the main trail. All of the hazard trees are possible candidates for partial or full removal. Even after adequate mitigation takes place with regard to trees, there should be a clear, simple sign indicating an ongoing threat of falling branches throughout the trail.

Waterfall: The attraction itself may be considered a potential hazard, as a scenic waterfall is also a zone of intensified water-induced erosion. The potential for rockfall is increased, infection from leptospirosis is possible as users tend to wade in the pool here, and the uneven boulders create a hazard in both slippery and dry conditions as users shuffle around to pose for the ideal Manoa Falls portrait. Exposure to these hazards is increased as hikers tend to linger at the destination.

Spur Trails and Flash Flooding: Although there are several signs prohibiting entry into restoration areas, several spur trails have appeared on either side of the trail. The fact that the trail does not run directly adjacent to Manoa Stream compels users to venture off the main trail to enjoy a view of the flowing stream. This increases the otherwise moderate flash flood hazard on this feature. Although there is little risk of getting lost by leaving the trail in this narrow valley, rescue efforts may be delayed in the event of injury.

Existing Management Practices: The Oahu Na Ala Hele staff regularly maintains their most used trail. Extensive trail maintenance occurs in the form of stairs, boardwalks, stonework, and gravel application. Aside from the obvious erosion from heavy use, the trail is in fairly good repair. Manoa Falls features signs warning against theft, leptospirosis, rockfall, and flash flooding at the trailhead, as well as permit requirements and restoration area considerations a short ways further, and finally keep out and rockfall signs at the destination. There are no map signs for the trail and no distance markers.

Possible Action Steps: As with most high-use trails, there is an urgent need to provide an adequate standard of care to reduce the probability that an incident with adverse effects would occur. The Manoa Falls Trail is a relatively short, well-contained trail that connects to the greater Honolulu Mauka system, however most hikers use only the route to and from the falls.

Although the signage is extensive throughout the trail, an over-abundance of signs can become decreasingly effective. Consolidating the informational and warning trailhead signs would reduce the cluttered appearance in that area as well as provide a standard format that would encourage users to stop and read the information. An overview of all hazards and variable conditions could prepare the trail user for the short hike ahead. Providing smaller signs at the point where a particular hazard might exist may increase awareness. One key to effective signage is to keep the number of signs to a minimum while communicating caution to prevent users from becoming indifferent to them.

The waterfall presents the question of whether to prevent hikers from reaching the falls, and doing so without sacrificing the natural setting. With increased usership of hiking trails in the state, particularly at Manoa Falls, the state may wish to consider an alternative that would both concerns of safety and the natural environment. Related to feature development is the issue of trail surface quality. With the high rainfall and visitor counts, traction will continue to be a problem on the Manoa Falls Trail. Innovative means to address this issue should be pursued. Development in the way of soil retention and boardwalks is one solution available to trail caretakers to prevent slip and falls as well as erosion.

Addressing the potential threat of harm from trees could possibly be accomplished with regular monitoring and selective pruning and removal. Finally, the flash flood hazard is significant only if the user ventures from the trail course. Spur trails exist not only for the thrill seekers, but also for those requiring restroom facilities that are not offered at the attraction. Purists may argue that building such an amenity is contrary to keeping the area in a natural state, but with as many users as there are on this trail, protection of the watershed is also a serious concern.

Maunawili Falls Trail, Oahu

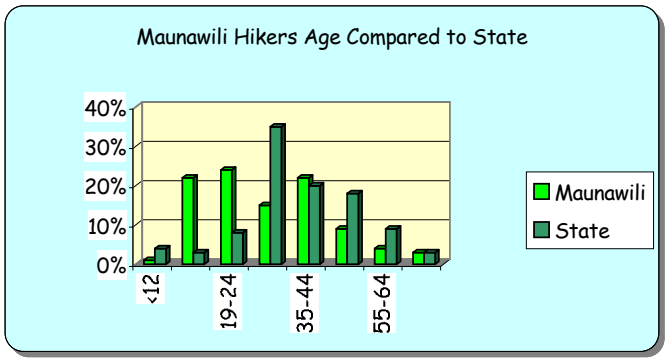
Maunawili Falls is a 2.6 mile roundtrip hike in Windward Oahu. This hike changes terrain from streamside to a ridge, and back through the stream. The trail is considered easy, quite muddy and very popular with local children. Maunawili Falls trail is best known by residents as a short hike with a great swimming hole and waterfall at the end. This gem of a hike is used almost solely by Hawaii residents (82%) and their out of state visitors (16%).

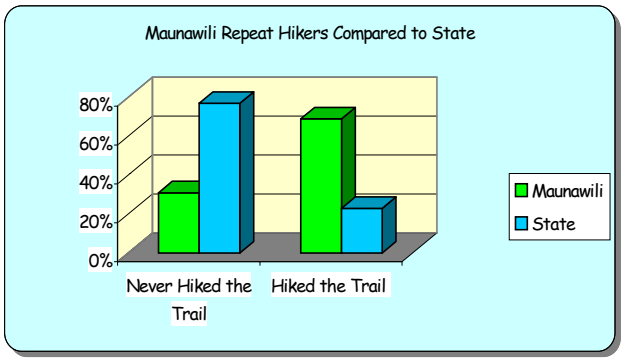
Hazards

Slippery trail, protruding roots and rocks
Falling rocks and branches
Leptospirosis
Mosquitoes
Cliff Jumping
Flash Flood

Maunawili Falls User Profile

This is a low to moderate use trail. The highest use occurs on weekends. Incredibly, 46% of hikers were between the ages of 12 and 24, while only 11% of the hikers surveyed statewide fell into that age category. Many of the hikers were headed to the falls to swim but most were hiking for exercise (66%) or to experience nature (27%). Several of the hikers expressed that they think of the hike as their neighborhood trail, this is shown by the comparative statistics; nearly 70% of hikers had hiked Maunawili Falls before whereas only 23% of those statewide were repeat hikers.

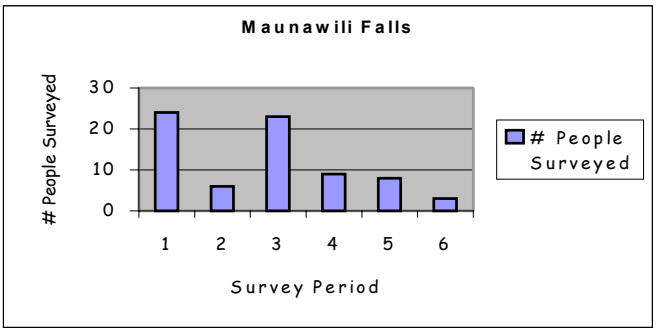




Social Profile of Trail and Trail Users

Survey Period Synopsis: The survey team set up at the trailhead. Three of the six survey periods it rained heavily. People hiked the trail despite the rain, although the number of hikers was higher on the clear days. The trail seemed to be well used after noon and on the weekends. Some people use the trail to walk their dogs in the evenings and on weekends. Most of the time, people exiting the trail were wet and muddy. Kids often entered the trail in slippers and swimming attire and on one occasion people were observed jumping from the top of the waterfall into the pool below. During all of the survey periods a film crew was using a site further into the forest near Maunawili Falls. This may or may not have affected the number of users.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Sunday	10:30-1:30pm	24
2	Friday	1:30-4:30pm	6
3	Saturday	10:20-1:20pm	23
4	Sunday	9:00-12:00pm	9
5	Thursday	2:30-5:30pm	8
6	Sunday	8:45-11:45am	3



Trail Conditions: The frequent Windward rains make the trail slippery and large puddles accumulate near the stream. Heading up toward the ridge, hikers felt the gravel was helpful for footing. The trail is signed for hazards but many signs have been defaced. Hikers remember a directional sign that used to point in the direction of the falls. Some non-local hikers found the absence of the sign confusing and some even ventured off in the wrong direction. In general people greatly enjoy this trail and many locals perform small trail maintenance while hiking (like removing fallen branches). Visitors commented that the trail offers a nice variety of environments. Near the end of the trail the path follows the stream in a deep gulch. The trail terminates at a pool where the steam spills in from the falls above. There have been reported cases of leptospirosis from those known to have been swimming at Maunawili Falls.

Physical Profile of Maunawili Falls Trail

The trail begins from a paved access road for a few hundred feet before veering off into a densely forested area. The consistently thick canopy is dominant for most of the route which crosses over Maunawili stream several times. The trail is well developed with several hundred stairs over Waikane silt clay (WpF2) which is a high erosion hazard. The mean annual rainfall of the area is 60-80 inches. The elevation gain is moderate. The trail surface is maintained to an excellent standard. There are five potential hazards that exist on the Maunawili Falls Trail: flash flooding, hazard trees, rockfall, steep stairs, and the destination itself.

Flash Flooding: Although the average annual rainfall in the vicinity of the trail is between 60 and 80 inches, the source of the Maunawili Stream is in the 100-120" isohyet. With the characteristically intense windward Koolau downpours, flash flooding is a potential threat to hikers. The trail crosses the stream five times, which would potentially cut off a user's return route in multiple places.

Hazard Trees: There were 14 potential hazard trees observed on the Maunawili Falls Trail. Albizia (*Albizia falcataria*), and mango (*Magnifera indica*) were the most frequent hazard tree species. Also observed were ironwood (*Casuarina equisetifolia*), formosa koa (*Acacia confusa*), avocado (*Persea americana*), hau (*Hibiscus tiliaceus*), waiawi (*Psidium cattleianum*), tropical ash (*Fraxinus uhdei*), and eucalyptus (*Eucalyptus robusta*). Most of these hazard trees were in the HT3-4 range with one albizia with a damaged branch directly over the trail rating an HT2.

Rockfall: There were three sections where rockfall could be a potential hazard: just before the trail junction at the 2/3 point, just before the stream crossing to the destination, and at the falls themselves. The first two sections are of moderate (<45%) slopes and well vegetated, but the

destination slopes are steep and agitation by divers into the pool may create a rockfall that may also affect users of the pool below.

Steep Stairs: Just before and after the junction with the Maunawili Demonstration Trail connector, the trail climbs and descends down a series of steep stairs without handrails, creating the possibility for trip and fall injuries.

Destination Hazard: Diving from the 15-foot cliff adjacent to the falls may not only create a rockfall hazard, but may be a hazard due to submerged rocks. Cases of infection from leptosprirosis have been traced to swimming in the pool at Maunawili Falls.

Existing Management Practices: There are numerous signs on the Maunawili Falls Trail warning users of various hazards along the trail. Signs are placed at the trailhead, where the trail veers off the access road, at the halfway point, and at restoration areas. The uneven trail surfaces have been heavily developed by the addition of boardwalks to reduce erosion and increase safety.

Possible Action Steps: Signage at the trailhead may be consolidated and placed near to the trailhead where a hiker check-in box could be placed. Larger trees could be regularly monitored for risk of falling over the trail, and be reduced or removed as necessary. A warning sign could be placed at the destination that details conditions at the pool and immediate area. Emergency escape routes could be developed and maintained in the event of a flash flood.

Nakoa Trail, Oahu

The Nakoa Trail is a 2.5 mile loop trail in Kahana Valley State Park. The trail features partial tree canopy for most of the hike and leads hikers across the perennial Kahana Stream twice. This valley is also a Class "C" public hunting area and contains a vast array of spur trails throughout the park. Although not technically a part of the trail itself, there is a pond at the end of the trail that is a popular swimming attraction.

Hazards

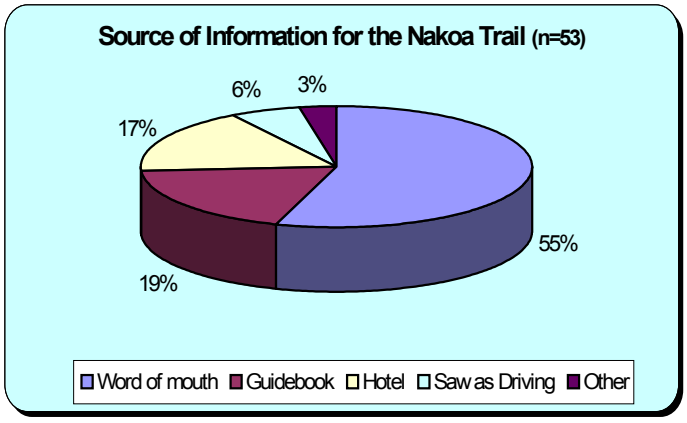
Flash Flooding

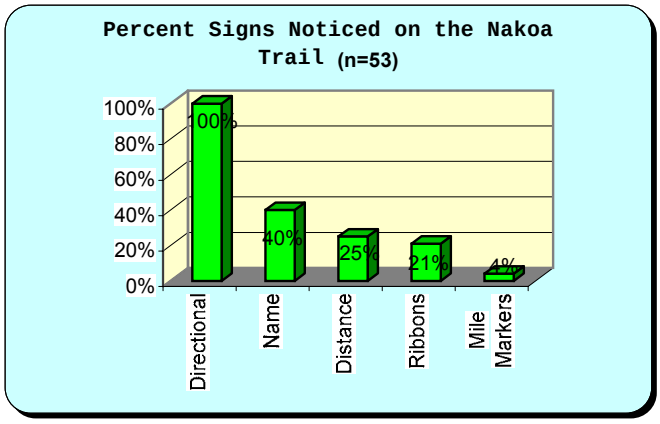
Disorientation

Hazard Trees

Nakoa User Profile

This is a moderate use trail visited by both tourists and locals alike. Those intending only to use the swimming hole a few hundred yards away from the trailhead were not actually on the trail and were not interviewed. Many of those who were swimming were assumed to be locals. Of those surveyed, 58% reported Hawaii addresses. More than half (55%) of those surveyed learned about the trail by word of mouth. Everyone responded that they remembered the signage on the trail and 83% said that they expected hazards on their hike.



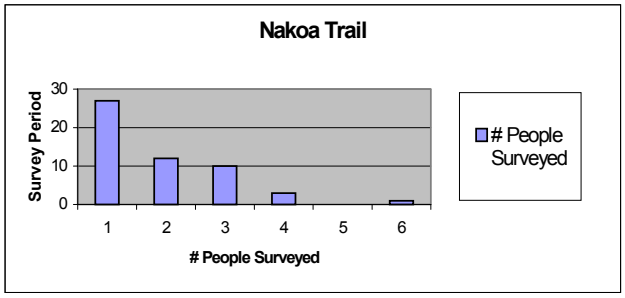


Social Profile of Trail and Trail Users

Survey Period Synopsis: The survey team set up right at the hunter-hiker check-in box, which is also the trailhead and junction of the access road to the swimming area. The park is heavily used by hunters and their vehicles could also be seen from the survey location. Hunters were often accompanied by several dogs. During one survey period, a hiker's house dog was attacked by a group of hunting dogs returning from the back of the valley and sustained visible injuries. Frequency of use fluctuated greatly between the first two and last four surveys. This may be explained by variation in weather, as the latter survey periods were during rainy and overcast conditions.

Many of the respondents thought that the trail was easy and well-signed. Although the trail is nearly three miles long, and measures almost five miles round trip from the designated parking area for hikers, several people commented that it was too short.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Saturday	12:30-2:30pm	27
2	Sunday	11:00-2:00pm	12
3	Sunday	2:00-5:00pm	10
4	Friday	10:00-1:00pm	3
5	Friday	1:00-4:00pm	0
6	Sunday	9:00-12:00pm	1



Trail Conditions: Colored ribbons and signs illustrating the hiker's progress along the trail help to keep users on the trail. There are numerous spur trails, most of which have had signs put up to direct hikers in the right direction. At the midpoint of the trail there are several remnant "pillboxes" that were built by the US Army in the 1950's when they used Kahana for training purposes. This provokes hikers to leave the intended course and reveals even more spur trails to the southwest. The trail surface is generally level and in good condition, but there are portions that are covered in serrated hala leaves, which can be slippery in wet or dry conditions.

Physical Profile of the Nakoa Trail

Flash Flooding: The Nakoa Trail crosses several intermittent streams and fords the perennial Kahana Stream twice. The first crossing is at about the halfway mark of the trail, and spans about twenty feet. The bottom is composed of small, unfixed boulders covered with slippery moss, which makes balance a challenge. The second crossing is at the swimming hole, and is across a concrete dam. The part of the dam where flow is directed features the same slippery moss on the rocks upstream. A cable assists the hiker across this last portion of the Nakoa Trail. Kahana stream is the receptor of the many tributaries for the valley. Average annual rainfall in the furthest reaches of the valley is the highest on the island, at 240 inches per year. Intense windward downpours can cause the stream to quickly become a torrent of storm water. If the stream rises after a hiker makes the first crossing, then he/she is faced with the option of crossing the dangerous stream or to leave the trail and venture to the northeast to exit the park.

Swimming Attraction: The swimming hole is a pond on the makai side of the dam at the end of the trail. The pond varies in depth from three feet along the edges to approximately ten feet in the center. There is a rope swing attached to a tree hanging over the northeast end of the pond, and a 12 foot cliff to the north at the base of the access road that leads back to the hunter/hiker check-in station. The water depth is sufficient to accommodate divers into the ponds from these points. The water depth in the northwest corner of the pond is less than at any other point, and features submerged rocks.

Falling Branches: Nearly the entire Nakoa Trail is under a canopy of native and exotic trees. Due to the extensive canopy cover along the trail, there were 32 potentially hazardous trees observed along the trail, nearly all of them were in the HT 3-5 range. Several of the potentially hazardous trees are candidates for mitigation in the form of removal, reduction or

retention. Although there are numerous examples of potentially hazardous trees on this trail, their approximate hazard rating is low enough due to the low use of the trail to be considered a moderate threat.

Disorientation: There are numerous spur trails from not only the Nakoa but also the access road to the trail. Those hikers who come to this undeveloped valley may desire to go beyond the moderate-length but relatively easy Nakoa Trail. Even the park information brochure indicates that if you take a turn at the pill boxes near the midpoint of the trail, there is the attraction of more pools and the back of the valley, where the trail route is less defined and hunting side trails abound. A further distraction are the ribbons tied to trees that are used by hunters and hiking clubs to mark their specific routes that often leave normal trail routes.

Existing Management Practices: The hunter/hiker check-in station is at the most appropriate location – where the loop begins and ends. It is plainly visible and features a map showing features in the entire valley. There is also information about the trail, but limited safety information. Signs show a general map course and current position at major spur trail points along the trail . Additional information, such as distance along routes and warnings about way-finding could serve to reduce the number of lost hikers.

Possible Action Steps: The stream crossings will continue to be challenging unless permanent infrastructure is installed. This may detract from the unspoiled beauty that attracts many of the users in the first place. Adequate signage that warns users of the slippery conditions concerning the stream crossings as well as a warning about the flash flood potential at both crossings is suggested as an option. At the swimming hole, a warning sign about submerged rocks is also suggested. Falling branches are likely to occur along the Nakoa Trail, which is 90% covered by tropical forest canopy. Regular inspection and maintenance of potentially hazardous trees and branches could potentially reduce this hazard. In circumstances where preservation of a potentially hazardous tree is preferred, then bracing and/or retention is a possible alternative to complete removal of the tree. A sign at either end of the loop indicating mature trees overhead with the possibility of breakage will help users to be aware of conditions above them. It is recommended that all spur trails be marked not just at the point of departure, but also a short distance from the main trail to assure that the stray hiker is informed of his/her decision to leave the suggested trail course and enter the hunting area. It is also recommended that safety information be included in the park information brochure and to discourage the avid hiker from leaving the main Nakoa Trail.

Island of Kauai

The Practicum group met with Craig Koga, Na Ala Hele Kauai Trail Manager, Ed Petteys, Kauai Division of Forestry Manager, Sam Lee, Kauai Land Division Manager, and other helpful Kauai DLNR staff on July 21st, 2000. Wayne Souza, Kauai State Parks Superintendent, was consulted by phone before and after the meeting. In this meeting, general hazards mentioned included the potential for flashfloods in trail corridors, slippery trail, rockhopping across streams, shared use conflicts (hikers, bikers, horseback riders, and hunters), rockfall, erosion, steep cliffs, falling branches, and the limited user knowledge of local conditions.

The following trails were proposed for consideration for survey purposes:

- Awaawapuhi – a moderate use trail; spur trails may contribute to lost hikers; sheer cliffs, slippery trail; bees & wasps
- Pihea – highest use trail in Kokee; estimate over 100 users/day; expect several unintended hikers who see sign while at lookout; slippery but wide trail in first section; sheer cliffs; boardwalk in swamp that may have sharp edges
- Keahua Arboretum – high use; estimate over 100 users/day; expect some users drive through on way to Mt. Waialeale; slippery trail, rocks, mudslide, leptospirosis
- Kalalau – estimate at least 150 – 200 users go to Hanakapiai, 2 miles in, each day; insufficient parking for users
- Iliau Nature Loop – high use trail in Kokee
- Halamanu Cliff – high use trail in Kokee
- Sleeping Giant – moderate use trail, used by many who do not want to drive all the way to Kokee

The trails selected were Awaawapuhi, Kalalau, Keahua Arboretum, and Pihea Trail. These areas vary widely in terms of use, environment, and potential hazards. Awaawapuhi and Pihea are both in Kokee State Park and Kalalau is in Na Pali Coast State Park; both parks are major tourist destinations on Kauai. Keahua Arboretum is at the end of a road after proceeding through a residential area; however, a significant amount of tourists visit simply while exploring. The trail is short at Keahua; while at Awaawapuhi, Pihea and Kalalau, the user has the opportunity to hike a long distance. All four trails are in a natural state, without improvements such as pavement or stairs.

There are differences among the users of these trails, which are explored further in the next section discussing the specific characteristics of each trail.

The trends that can be seen among the trails on Kauai:

- Most users hiked in pairs
- With the exception of Keahua (70%), more than 85% of the users were visitors
- The most popular reason for hiking was to see the views
- With the exception of Keahua, most users heard about the trail from a guidebook
- More than 75% of the users were visiting the trail for the first time
- Nearly 58% of the users had hiked other Hawaii trails
- Less than 36% of the users notified someone not with them of their intended hike
- Less than 16% of the users had ever gotten lost while hiking
- Most users considered the trails of intermediate difficulty (Keahua excluded)
- Most users considered themselves intermediate level hikers

Awaawapuhi Trail, Kaua'i

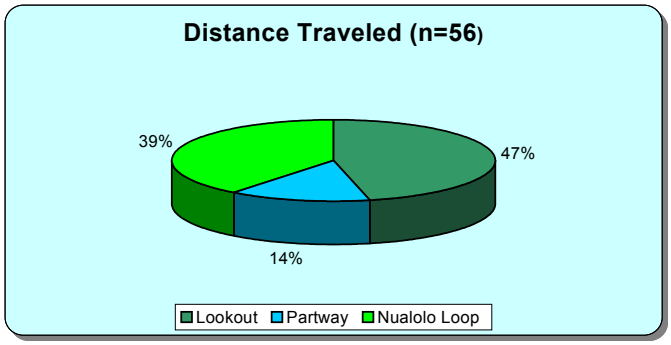
The Awa'awapuhi Trail is a Na Ala Hele trail that begins in Koke'e State Park. The trail traverses nearly three miles downhill through beautiful, high altitude forests but at times changes from the forest onto the exposed ridge. The trail culminates in an open grassy area with a view into an unspoiled valley and out onto the sea beyond the jagged Na Pali coastline. The hike retraces the same path back but this time the hike is unrelentingly uphill. It is best to begin the hike in the morning as the area has a tendency to fog in during the afternoon. The majority of the people surveyed felt this was an intermediate hike (59%) but the view at the end is worth the trouble.

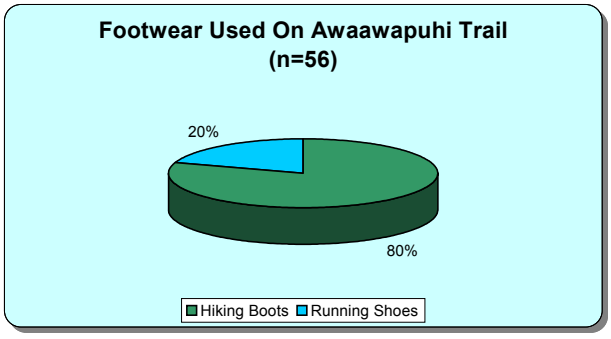
Hazards

Rapid changes in weather conditions
Strenuous uphill climb
Steep Cliffs
Exposure to climate
Falling rocks and branches
Heat

Awa'awapuhi User Profile

This is a moderate use trail, visited primarily by non-locals. (9% local and 91% non-local). The highest uses occur between 11AM and 3PM. Many people are starting at the Kokee Lodge and hiking the eleven mile route on the Nualolo Trail until it meets up with the Awa'awapuhi trail. These hikers have to do the strenuous three miles of uphill hiking at the end of their first eight miles. Most hikers understood Awa'awapuhi is a relatively difficult trail and carried appropriate equipment. The majority of the hikers on this trail considered themselves either intermediate (57%) or advanced (27%) hikers.



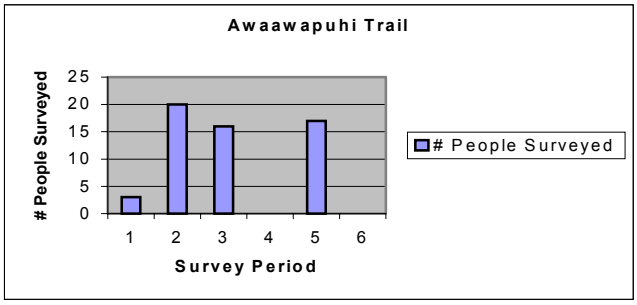


Social Profile of Trail and Trail Users

Survey Period Synopsis: The survey team set-up right next to the parking area at the trailhead. All of the survey periods fell during hunting season. As a result, there were many hunters in Kokee and several were seen on or nearby the trail. This was noticed by several of the hikers that were surveyed. Many people expressed concern about the proximity of the hunters to the recreational trail. One group mentioned that they were not notified it was hunting season and would have appreciated being advised to wear brighter clothing at the trailhead. Generally hikers did not arrive at the trail until late morning. The survey team believes this is because the major resort areas are a minimum of an hour and a half drive from the trail.

On a few occasions the survey team was approached for more information about the trail (level of difficulty, length, what there was to see, etc.) Many times, the potential hikers decided not hike after receiving more information about the trail. These visitors thought a placard at the trailhead describing the trail would be helpful to those considering the hike. A few of the people surveyed admitted they went beyond the point at the edge of the cliff where the sign advises not to go any further. These hikers confessed that they would have attempted this regardless of markings or fencing. Two groups felt a sign-in sheet would be a good idea.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Saturday	9:30-12:30pm	3
2	Saturday	2:00-5:00pm	20
3	Friday	2:00-5:00pm	16
4	Saturday	8:45-11:45am	0
5	Saturday	1:40-4:40pm	17



Trail Conditions: Mile markers and species identification markers help hikers keep their bearings. The trail surface is dirt, roots and fallen koa leaves under the forest canopy. On the exposed ridge the trail is more rocky and a little crumbly. Many people were impressed with the maintenance of the trail. Some people wished they had worn sunscreen or a hat and carried more water.

Physical Profile of Awaawapuhi Trail

The Awaawapuhi Trail begins in a mature ohia (*Metrosideros polymorpha*) forest on a gentle downward grade. The trail surface is in excellent condition throughout the 2.75 mile course. There are no stream crossings on the trail. The trail is in the 60-70" mean annual rainfall isohyet. The elevation difference from start to finish is about 1,600 feet. The beginning of the trail travels beneath a sporadic forest canopy that eventually dwindles to the point where it provides very little cover. However, the primary potential hazard on this trail is trees. Other potential hazards include landslides and fatigue.

Hazard Trees: Although not under a significant canopy, there are a considerable number of potentially hazard trees along the Awaawapuhi. In total, there were 52 possible hazard trees observed in nearly equal number of two varieties: koa (Acacia koa) and ohia (Metrosideros polymorpha). The first mile features only ohia hazard trees with respect to the trail course, but most are in the HT 3-4 range and constitute neither an immediate threat nor a challenge to remove. From an exclusively ohia forest, the trail progresses down slope to a drier koa forest. One koa subject in particular was rated as HT-1 due to a hanging branch that extended 20 feet directly above the pathway. The support to the branch was so slight that the branch would freely sway to the touch. In this case, immediate removal would be the only solution to this hazard. Many of the hazard trees noted were branches that had separated but were prevented from falling to the ground by adjacent branches.

Landslides: At the 1.5 mile marker, the trail is no longer covered by tree canopy. The first vista on the trail is also the first potential slope hazard. The view improves as one approaches the edge, which is actually the edge of a previous slope failure. The hiker is actually standing on an unsupported overhang with a drop of nearly one hundred feet. There is evidence of other relatively recent slope failures in this drier region. Near to the 2 mile marker is a short spur trail

that promises an improved view of the surrounding canyons, encouraging hikers to stray from the main trail. Finally, the destination itself is a precipice that features the first handrails on the trail, which by evidence of extensive erosion are ignored by the users.

Climate & Topography: Due to the open exposure to solar radiation and the excessive elevation change, exhaustion is a possibility. Hikers who are in poor physical condition or do not carry food and/or water will find this hike to be a significant challenge.

Existing Management Practices: There is evidence that tree removal has taken place along the trail. Large koa that may have considerably blocked the trail were sawn and the logs cast alongside the path. There were also many older fallen trees that were probably victims of Hurricane Iniki in 1992. Division of Forestry and Wildlife maintenance crews perform regular upkeep of the trail.

The sign program is very straightforward. A trailhead sign warns users to "hike at your own risk" and there are low-set quarter-mile markers. There is a trail junction sign and an end of trail sign. Handrails are only used at the destination viewpoint.

Possible Action Steps: Most of the potential hazard tree situations call for review by a professional. Many of the living koa should not require complete removal, but many of the ohia are either dead or in poor condition. However, the removal of 52 trees, many of which reach heights of 40 feet and have diameters between one and three feet, would require a substantial amount of manpower and resources.

The amount of signage appears sufficient, but the information at the trailhead could be expanded to include information about hazards, approximate total hike time, and elevation change. A hiker check-in box could help with trail use management. Handrails could be installed at the 1.5 mile marker overhang at a setback.

Kalalau Trail, Kauai

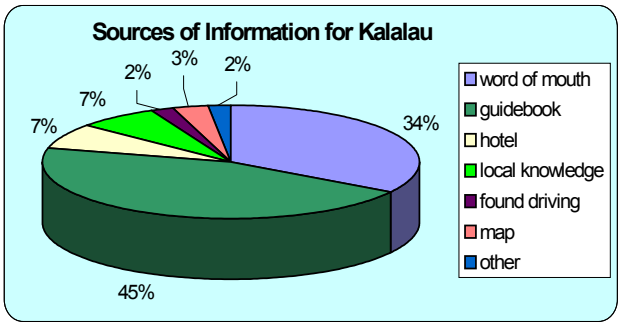
Kalalau Trail is located in the Na Pali Coast State Park, one of the major destinations for visitors of Kauai. The Kalalau Trail skirts the Na Pali coast on Kauai for nearly eleven miles of highly challenging hiking. Due to the rugged terrain, dramatic elevation changes and beating sun, this is a trail for well prepared hikers and beyond Hanakapiai Beach, is accessible only to those with a permit. However the breathtaking views and the promise of a secluded beach and awe-inspiring waterfall draw those less experienced into the Kalalau Trail. The Kalalau Trail is world famous for its spectacular scenery yet unbeknownst to many, its beauty is a result of many unpredictable hazards.

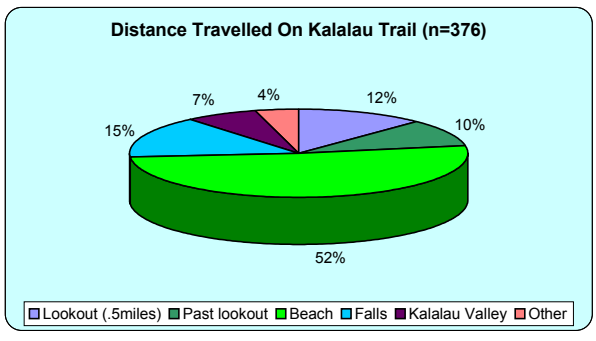
Hazards

Slippery trail, protruding roots and rocks
Falling rocks and branches
Leptospirosis
Extreme exposure to weather/sun
Strenuous climb
Steep cliffs
Flash Flood
Dangerous shore break and rip tide

Kalalau User Profile

This is a very-high use trail, visited primarily by visitors (13% local and 87% non-local). Hikers have a wide range of experience levels with most hikers considering themselves either beginning or intermediate hikers. Interestingly, hikers on Kalalau were overall less experienced than the state average. Almost 80% of the people surveyed were hiking Kalalau for the first time yet more than half of those surveyed had hiked other Hawaii trails before. The majority of people hiked to Hanakapiai Beach (52%) and back out.

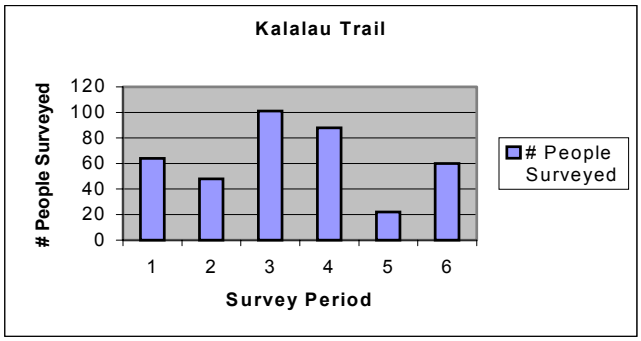




Social Profile of Trail and Trail Users

Survey Period Synopsis: Surveys were taken at the trailhead, past the kiosk, by the sign at the trailhead. The parking lot was significantly less crowded than it had been in July during our scoping trip. The survey team believes this was due to surveying after the peak tourist season. The survey team was approached by many hikers with questions about the trail; mainly how far to the first lookout and how far to the beach. The survey team was commonly mistaken for park attendants and were asked if they needed to check-in before hiking. In addition many hikers requested water, maps, mosquito repellent, hiking permits, and t-shirts from the survey team.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Friday	10:30-1:30pm	64
2	Saturday	10:10-1:10pm	48
3	Saturday	1:45-4:45pm	101
4	Friday	1:20-4:20pm	88
5	Saturday	8:25-11:25am	22
6	Saturday	11:25-2:25pm	60



Trail Conditions: Some parts of the trail may be slippery due to mud, other parts may by slippery due to settled dust and crumbling rock. The trail surface is uneven, consisting of rocks, roots, and mud. Informational and hazard warning signs were present at the trailhead. Mile markers are placed every half mile but can be difficult to find. Warning signs are placed just before Hanakapiai Beach about dangerous rip tide and tsunami. Directional markers to the falls and the Kalalau Valley are incredibly difficult to find. Many people were observed venturing in the wrong direction in search of the falls.

Physical Profile of Kalalau Trail

The entire length of the Kalalau Trail is 11 miles. The first two miles to Hanakapiai Beach were surveyed for this study, due to the high use of this section and the limited scope of this report. The trail begins with a moderate incline over rock outcropping (rRO) and rough mountainous land (rRT) through a mixed-ironwood (*Casuarina esquisetifolia*) forest. The trail weaves in and out of several small valleys/drainageways with sparse to no canopy cover. Some portions of the trail are man-made stone pathways. The average annual rainfall of the area is between 60 and 80 inches, although the trail was considerably drier during the mid-September survey. There was only one hazard tree (*Acacia koa*; HT3) observed and two stream crossings. The elevation gain/loss is about 600 feet. There are four potential hazards that exist on the Kalalau Trail: rockfall/steep cliffs, flash flooding, exposure/fatigue, and slippery trail.

Rockfall/Steep Cliffs: The two-mile trail curbs the moderate cliffs of the east Na Pali coastline through rock outcroppings. There are five areas of potential rockfall hazard ranging in length from 15 to 50 feet in length. This potential hazard is exacerbated by the presence of tap-rooting ironwood trees. The roots loosen the already-fragmented rock in search of water, gradually freeing individual and clusters of rock near to the trail. The maximum elevation between Kee and Hanakapiai beach is 620 feet, with some of this slope being sheer to sea level. The hazard is increased due to the eroded and shifting soils on the trail.

Flash Flooding : At about 1.75 miles, there is a minor creek crossing that may pose a problem for users returning from Hanakapiai beach or further in the event of a sudden rise in stream flow. The stream at Hanakapiai is a higher volume stream and would present more of a challenge in the event of a flash flood.

Climate & Topography: There is very little canopy along the Kalalau Trail, which exposes the user to an average solar radiation intensity of 200 watts/square meter. There are no sources of potable water on the trail.

Slippery Trail: Although the trail is relatively dry, intense use leads to erosion and loose shifting soils that can be particularly hazardous on the descent near to the destination. Heavily eroded shortcuts through the short switchbacks are steeper and more hazardous than the main trail. During the rainy season, the trail can become very muddy and therefore slippery.

Existing Management Practices: A kiosk at the trail head provides comprehensive information about the trail, including leptospirosis. Other signs include a half-mile and one-mile marker along the trail and ocean-related warnings upon reaching Hanakapiai Beach. The vegetation along the trail is regularly cut back.

Possible Action Steps: Parts of the trail feature wooden supports. An extension of this effort would reduce the rate of erosion as well as increase user safety. Gravel could be added to the root-covered sections near the trailhead to level out the trail surface, but due to the high use of the trail, the gravel may not last long. There is little that can be done about the exposure factor aside from posted warnings about clothing and water. In the same respect, there are no practical alternative routes to avoid the stream crossings in the event of a flash flood. One option to address the potential rockfall hazard is the selective removal of some rock clusters and the retention of rocks affected by ironwood, however this latter option is only a temporary solution. Steep slopes will continue to be a potential risk on the Kalalau Trail, but installing handrails may not be a desirable reaction as it may detract from the natural beauty of this world-renowned feature. Appropriate signage is always another option to address the potential hazards.

Keahua Arboretum Trail, Kauai

Keahua Arboretum is home to mango, monkeypod, and eucalyptus trees. The streams are filled with life, and there are pools in which to swim. Picnic tables are scattered here and there and Mt. Waialeale sits as a backdrop for the beautiful preserve. The trail begins at the end of Highway 580, and is a half mile long. This outdoor nature trail is like a biology classroom. This is a great place to picnic, stroll or swim.

Hazards

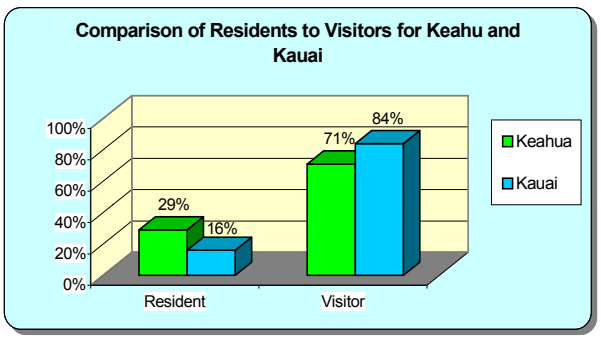
Trail Surface

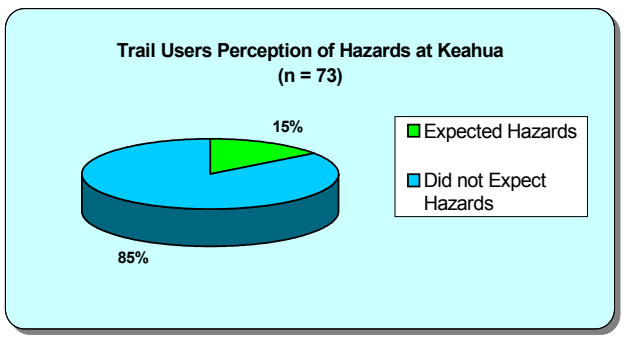
Swimming ponds

Flash Flooding

Keahua User Profile

This is a moderate-use trail. People use the Arboretum for a mix of activities, including picnicking, swimming, bicycling, horseback riding, and strolling along the trail. Majority of the users were tourist who read about the Arboretum in a guidebook or map(29% resident and 71% visitor). However the number of residents here is higher than the state average, with 30% of the users as local residents who utilize the Arboretum on the weekends. There were a few unintended users who went to visit Opaeka Falls and decided to continue on the road to see where it led.

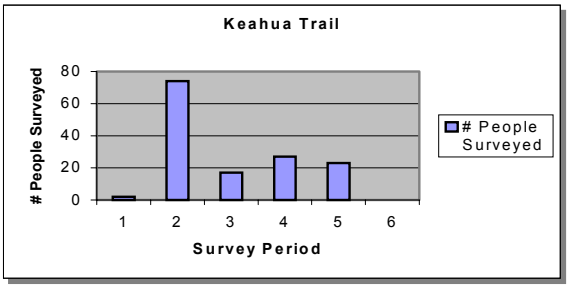




Social Profile of Trail and Trail Users

Survey Period Synopsis: The survey team established camp within the Arboretum, after the stream crossing. Only people who got out of their cars and walked around were interviewed, but the survey team noted that this constituted a small percentage of the total visitors: the majority either turned around or exited their car for seconds to take a photo. During the survey periods the Arboretum was overgrown because it was being used as a backdrop for the filming of Jurassic Park III. The trail that meanders through the park was hidden and unusable at this time, leaving some users wondering where they were suppose to go to hike. Other users asked about plant identification tags or a sign that describes the park and its significance. A majority of the users were happy just by being able to stretch their legs and find a restroom. The survey team observed some usage beyond the Arboretum along the 4WD trail. Most of the users were hunters, but a few daring tourist risked the rocky road with their rental cars.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Friday	3:00-5:30pm	2
2	Sunday	10:00-2:00pm	74
3	Friday	8:25-11:25am	17
4	Sunday	8:00-11:00am	27
5	Sunday	11:00-2:00pm	23



Trail Conditions: When maintained, visitors can stroll along the quarter mile path that guides you from the parking area of the Arboretum to the top of a small hill that overlooks a large open field, then along the stream where you can stop for a picnic lunch. The trail is often times muddy and slippery, but has no threatening hazards. However, during heavy rains the stream can flood, making crossing difficult and potentially hazardous.

Physical Profile of Keahua Arboretum Trail

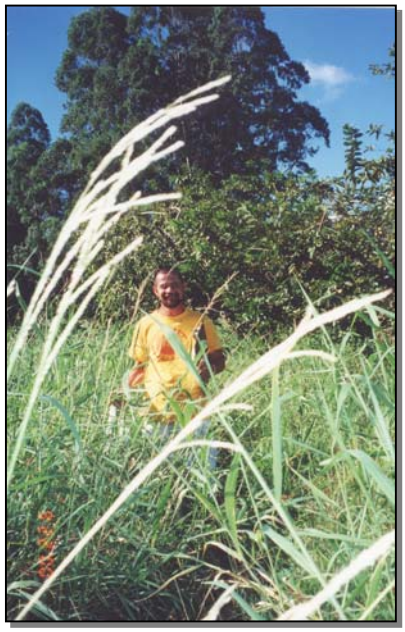
This short trail is not signed as a trail, but it is in fact a loop trail that skirts the south end of the stream to a small pond and switches back to a grassy area that leads back toward the road. The layout of this Na Ala Hele feature resembles an open park, with four picnic canopies located on either side of the stream. Two cemented areas on the northern bank cover up what once were short Hawaiian *holua* slides to prohibit entry into the stream. The primary hazards are the two shallow swimming ponds along the stream: one where the stream crosses over the road and the other on the far east end of the short loop trail. Although this is an arboretum, the large trees (mindinao gum [*Eucalyptus deglupta*]) in the vicinity are in excellent condition and pose only a baseline HT5 threat. There are also no hazards associated with slope of the terrain. There are three potential hazards that exist in the immediate Keahua Arboretum area: trail surface, flash flooding and the swimming ponds.

Slippery Trail: Although the trail route is rather short, the path just beyond the pond is of a slippery, angled rock outcropping several feet above the waterline. The high annual rainfall keeps the trail and rock outcropping saturated.

Flash Flooding: While the mean annual rainfall at the arboretum is between 80-100" per year, the stream source area receives more than 200" and is near to Mt. Waialeale, the acknowledged wettest place on earth. Sudden changes in the weather could have a significant impact on the stream bisecting the arboretum, trapping users as well as their vehicles in the parking lot located across the stream. Although users are advised to enter the water at their own risk, the banks are high and prohibit quick escape. Gnarled hau (*Hibiscus tiliaceus*) bush downstream in the water may make exiting a rushing stream difficult in the event a user is swept off by increased flow.

Swimming Ponds: The high banks of the stream pond provide an attractive jumping off point, making that swimmer susceptible to injury by concealed rocks. Users have been observed jumping from the low banks and into the shallower roadside pond as well. Signs were present but not heeded. The sign adjacent to the far pond was vandalized at the time of the physical survey on 9/15/00 and should be replaced.

Existing Management Practices: Despite warning signs at the arboretum entrance, no signs pertain to the loop trail. Although classified as a trail in the Na Ala Hele Trail and Access System, it is managed in a park-like setting as users are invited to roam around an extensive area rather than a linear feature.



Possible Action Steps: Signs could illustrate paths and warn about hazards, particularly related to the stream. The signs should be periodically checked to assure that they are in satisfactory condition. The slippery trail hazard cannot be effectively addressed without substantial development which if usership at the arboretum increases could be considered. In the future, if another intentional grow-out of the vegetation along the trail takes place, temporary signs could be installed to inform visitors of the concealed trail route.

Pihea Trail, Kauai

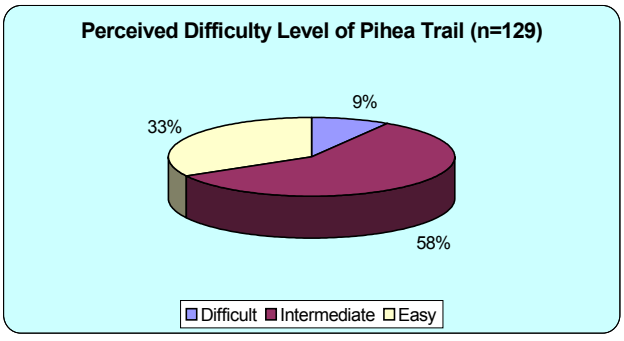
At the end of Road 550 in Kokee State Park, the Pu'u o Kila Lookout attracts many visitors for its astonishing views of the Na Pali Coast. The Pihea Trail starts at the lookout and clambers along the cliffs for almost a mile to a vista. At that lookout the trail descends into ohia forests and the Alaka'i Swamp. After the intersection with the Swamp trail the Pihea Trail traverses another mile and terminates at a lookout of Hanalei Valley. The entire trail is seven miles roundtrip, although very few people hike the entire path. Many of the Puu o Kila Lookout visitors begin the hike believing they will have a better view from the trail. Like other Kokee hikes this trail can fog in completely and without warning. The majority of the people surveyed felt the part of the trail they hiked was an intermediate hike (58%).

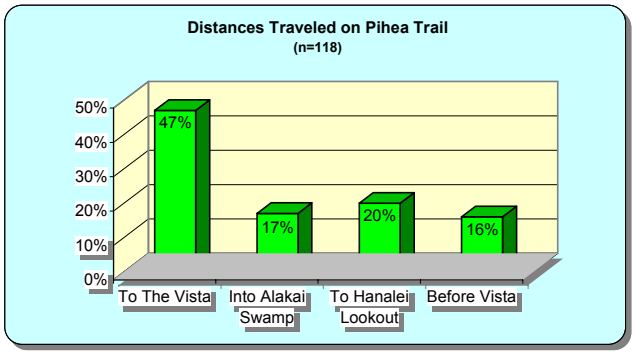
Hazards

Rapid changes in weather conditions
Falling rocks and branches
Steep Cliffs
Mud
Uneven Terrain

Pihea User Profile

This is moderate use trail, visited primarily by visitors (11% local and 89% non-local). Many of the hikers had not originally intended to hike when they arrived at the lookout. The majority of the hikers on this trail considered themselves either beginning (22%) or intermediate (61%) hikers. Most people hiked only to the vista (47%). Those that traveled farther (to the swamp (17%) or to Hanalei Lookout (20%)) had more equipment and higher experience levels.

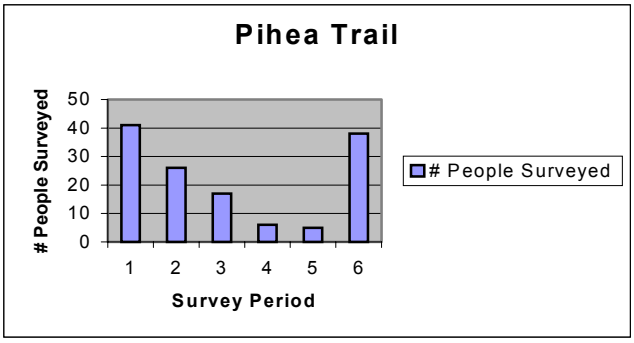




Social Profile of Trail and Trail Users

Survey Period Synopsis: The survey location was about a third of a mile into the trail. Because so many people venture away from the Lookout in search of a better view, the survey team felt that surveying non-hikers could be prevented by setting up further into the trail than usual. People seem to come in waves to the trail. The survey team inferred that this was a result of one car setting the pace for many followers on Road 550. Most of the time the weather was clear until around noon when fog would prevail for most of the afternoon. Two survey periods were miserably cold and windy. During those periods the number of hikers was much lower than during other days when it was clear or sunny. The survey team believes weather played a big part in whether or not people chose to hike. The highest uses were observed between noon and three in the afternoon.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Friday	1:00-4:00pm	41
2	Sunday	9:30-12:30pm	26
3	Sunday	2:00-5:00pm	17
4	Friday	10:00-1:00pm	6
5	Sunday	8:15-11:15am	5
6	Sunday	11:15-2:15pm	38



Trail Conditions: The trail is marked with directional arrows, mile markers and description signs. Some people felt the signs at the intersection of the Alakai Swamp trail were confusing. Many people did not know how much farther it was from the intersection of the trails to the Hanalei Lookout so they never attempted the last leg of the hike. Several people commented that they were very impressed by the boardwalk through the swamp. The portion of the trail closest to the lookout parallels the cliff where many people were observed approaching the edge and where a strong gust of wind could be dangerous. Several people lost hats and other loose items over the edge.

Physical Profile of Pihea Trail

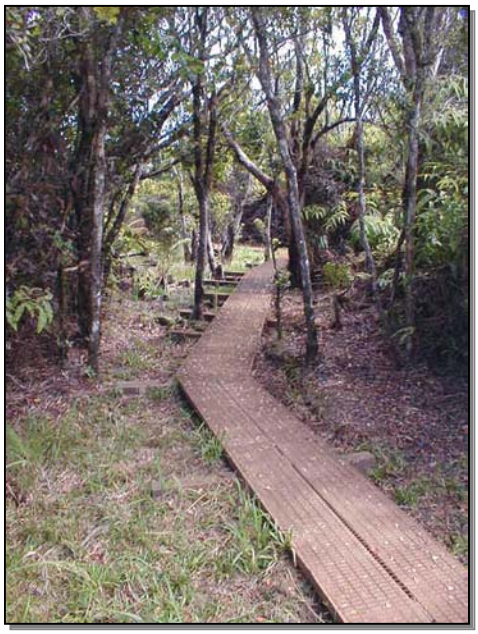
The Pihea Trail hosts two different environments through which it passes. The beginning is a high lookout point with a vista of the entire Kalalau Valley. View-seekers become trail users when they venture down the severely eroded path east along the rim of the famous valley. Although the Kokee silty clay loam erosion hazard is only slight to moderate, the 120" of average annual rainfall and heavy use compacts the soil and prohibits the re-establishment of vegetation. Uluhe (*Dicranopteris linearis*) and small ohia lehua (*Metrosideros polymorpha*) are the dominant species over the first mile of trail along the valley rim. As the trail continues to the southeast through the Alakai Swamp, the trail surface is a double 2" x 12" boardwalk wrapped in wire mesh. There is no canopy over the trail, and only one potential hazard tree, an ohia, was observed. The surveyed 1.75 mile section of the trail spans between the Kalalau Lookout and the Alakai Swamp junction. There is a short, designated spur trail called the Pihea Vista just beyond where the Pihea Trail veers toward the swamp. There is little rockfall hazard and there are no stream crossings on the trail. In all there were 2 hazards observed on the Pihea: high cliffs and slippery trail.

Steep Cliffs: The Kalalau Lookout is a wide concrete platform from which to view the expansive valley below, complete with handrails. From the wide, eroded trail, the user is unrestrained from venturing to the very edge of the precipitous cliffs. This, combined with the loose soil and gusty winds typical of the area, constitutes a potential hazard.

Trail Surface: Through heavy use and high rainfall, the inclines between the .75 and 1.0 mile markers as well as the climb to the Pihea Vista are severely eroded clay stairs. Exposed tree roots due to this erosion act as handholds to pull hikers to the next level. The first quarter mile of the trail is a moderate down slope over loose soil and the rock outcropping. Any rainfall increases the difficulties with

traction. Although the boardwalk on the swamp portion of the trail is covered by wire mesh, it still becomes slippery in wet conditions.

Existing Management Practices: The trail is well signed, complete with mileage markers. There are two sections where stairs have been developed to mitigate erosion, but much of the inclines on the trail are badly eroded and would possibly benefit from improvements, particularly in response to the high use of the trail.



Possible Action Steps: With regards to the high cliff hazard, the response could be the installation of safety rails, a more defined trail route within the eroded area, or a combination thereof. Designating a trail course would prevent extensive erosion and random wandering of trail users. Stair construction is recommended for the Pihea Vista area and the first quarter mile over the rock outcropping. This would also help to control the severe erosion on this part of the trail and increase user safety. The one hazard tree, located along the boardwalk section, is in poor condition and should be removed.

Island of Hawaii

The Practicum group met with Rodney Oshiro, Na Ala Hele Big Island Manager, Allen Takada, Hawaii State Parks, and Wesley Uyeda of Hawaii Land Division, on August 21st, 2000, to discuss the scope of evaluation on the island of Hawaii.

The following trails were proposed for consideration for survey purposes:

- Ainapo – a low use trail which climbs to the summit of Mauna Loa. Due to the altitude of the trail, hikers may misjudge the length of the trail and their abilities in these conditions.
- Upper Hamakua Ditch – a moderate use trail used mostly by locals. Hazards include sheer drops, slippery trail conditions due to local climate and hazard trees.
- Pololu Trail – a relatively high use trail, with potential ocean hazards due to its location. Managing users to stay on public land is also a problem.
- Kahaualea Trail – a low use trail, but one near the active Puu Oo volcano which could be hazardous to those who go beyond the trail's end point.
- Hapuna State Park – a park with primarily ocean hazards related to high surf and a rocky shoreline.
- Boiling Pots – an area used mostly by locals; though not actively advertised, people frequent this area to swim and to jump off the falls which can be dangerous.
- Kehena State Park – a beach park known to have strong ocean currents along the park.
- Muliwai- one of the more challenging hiking trails on the island, with moderate use.

The trails selected were Ainapo, Muliwai, Kahaualea, and Upper Hamakua Ditch. All are maintained in a mostly natural state. These trails vary widely in terms of use, environment, and potential hazards. These variations are reflected in the data received by the users of each trail.

Trends noticed on the trails of the Island of Hawaii:

- Most users hiked in pairs
- Hamakua Ditch trail was about an equal gender split, whereas Muliwai was 2/3 male
- A wide distribution of ages on the Ditch trail, but 88% of Muliwai users were in the 25-34 year old age group
- Visitors accounted for 88% of the users of Muliwai, while only 43% of Ditch Trail users were non-residents
- 23% of users on the Hamakua Ditch Trail were students

- To experience nature, see the view and exercise were the most popular reasons for going hiking
- Everyone who was interviewed accessed the Big Island trails by car.
- 75% of Ditch Trail users learned about the trail by word of mouth, while half of the Muliwai hikers read about it in a guide book.
- A little over half of the Ditch Trail users had never hiked there before, whereas all but one (88%) of Muliwai hikers were first timers.

Ainapo Trail, Hawaii

The Ainapo Trail is located on the southern slope of Mauna Loa Volcano on the Big Island, near Volcanoes National Park. The trailhead lies at the end of an eight-mile four-wheel drive road. The distance from the trailhead to the Ainapo Trail Shelter at Halewai is approximately 2.7 miles. The trail winds through mixed-mesic koa ohia forest and older pahoehoe lava flows. After Halewai, the trail ascends for another 7.5 miles to the Mauna Loa cabin on the rim of Mokuaweoweo. The latter section of the trail is considered challenging and should not be attempted by novice hikers or those unfamiliar with the extreme environmental conditions, which may be encountered.

Hazards
Hazard Trees
Climate and Topography
Conflict of Use
Disorientation

Ainapo User Profile

This is apparently a low-use trail since we encountered no hikers during our survey periods. The lack of activity is most likely due to the limited information available in guidebooks about the trail and the difficulty in reaching the trailhead. There was a group of four hunters encountered on the trail, but they related that they spent most of the day off-trail.

Social Profile of Trail and Trail Users

Survey Period Synopsis: The first survey period was to be on September 30th; however, the team was not equipped with a four-wheel drive vehicle and was unable to reach the trailhead. The second survey took place on October 21st for five hours between 8:30 and 1:30pm. No hikers were encountered, but the aforementioned group of hunters was approached for discussion. There were three trucks (2 groups) noticed in the parking area.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Saturday	8:30-11:30am	0
2	Saturday	11:30-1:30pm	0

No Users Surveyed

Trail Conditions: The trail has minimal signage, and the colored tape and ahu (stone markers) are sometimes placed arbitrarily. The trail is a steady climb of 2,100 feet over the first 2.7 miles. The trail surface was in moderately good condition, with some uneven sections over older pahoehoe lava flows.

Physical Profile of Ainapo Trail

The entire length of the Ainapo Trail is ten miles. It begins at 5,600-ft elevation and travels to the Ainapo Trail Shelter at 7,700-ft. elevation, then on to the Mauna Loa cabin at the rim of the Mokuaweoweo Crater. The first 2.7 miles to the Ainapo Trail shelter were surveyed for this study. The trail begins in the Kapapala Forest Reserve eight miles from Highway 11. The trail is accessed by Ainapo Road which requires four-wheel drive vehicles and travels primarily through the privately-owned Kapapala Ranch. Generally, clear skies in the early morning are replaced by foggy conditions in the early afternoon. Beautiful native forests and bird life abound on and around this remote, low-use feature. The area is primarily used by hunters which explains the ubiquitous spur trails. Rainfall over the length of the trail ranges between 80 and 120 inches per year. Soil types for this area include Kekake extremely rocky muck (rKHD), Kahalu`u extremely rocky muck (rKAD), and Hydrandept-Tropofolist association (rHP). The trail between the trailhead and the Halewai cabin runs through sparse canopy.

The trail begins at a wide parking area with a trailhead sign featuring printed fliers available from the Department of Forestry, Hilo branch. Hazards listed in this flier include tree molds and lava tube skylights off the trail, and the flier alerts to shared use with hunters. The trail climbs the moderate incline through mixed mesic koa-ohia forest marked by ancient ahu (stone cairns – stacked rocks indicating direction) where the trail route becomes questionable over the old pahoehoe lava flows. Colored ribbons also help to mark the trail route. There were four potential hazards observed between the trailhead sign and the Ainapo Trail Shelter (Halewai): hazard trees, exposure, shared use, and disorientation.

Hazard Trees: The largest koa (*Acacia koa*) trees observed as part of this study were found on the Ainapo Trail. When a koa tree exceeds its optimal size, the limbs get so large that they break from their own weight. There were six potential hazard trees observed on the trail, all of which were koa. The hazard koa were generally rated in the HT2 category due to the severity of the fracture or dislocation of limbs and the size of the specimen, however, the exposure to the

user was very brief. Trunks of two of the fractured koa had almost no support and the fall would be directly to the trail.

Exposure: Although the trail runs through a forest reserve, there is very little solid canopy above the trail. The direct exposure to the sun is offset by the characteristically foggy conditions and high elevation of this thermocline.

Shared Use: This is a hunting destination trail. Hikers should be aware that the area is actively used by hunters with dogs, and should also be encouraged by signage to wear brightly colored clothing for visibility.

Disorientation: At various points along the route, the trail becomes difficult to discern in the fields of the pahoehoe flow. The stone cairns and colored tape generally mark the route, but are sometimes far apart or exist on more than one route, causing possible misdirection and backtracking.

Existing Management Practices: The trailhead sign is the last language marker before reaching the Halewai cabin, which gives distance traveled and remaining to the summit. The ahu and colored tape are the only other signs of trail management.

Possible Action Steps: Although the trail is very low use, potential hazards existing on the trail should be addressed to reduce the need for rescue on a remote trail. A check-in box could be placed at the first gate and trail sign near to the highway. Quarter-mile markers and directional signs at confusing junctions could be installed to help users remain oriented and on pace. Potential hazard trees should be considered for removal since retention of old koa trees may not be practical. Hikers could be warned about hunting activities at the highway gate rather than at the trailhead eight miles away.

Hamakua Ditch Trail, Hawaii

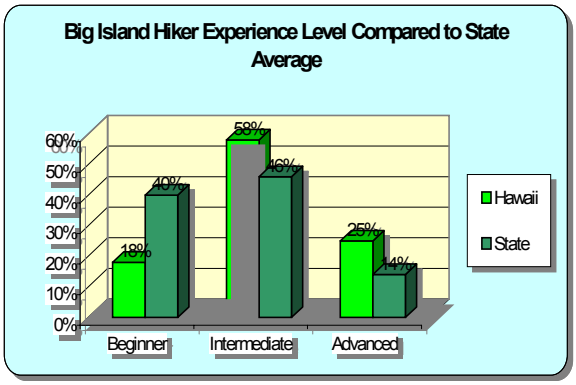
The Upper Hamakua Ditch Trail is managed by the Division of Forestry and Wildlife and is in the Kohala Forest Reserve on the Hamakua Coast of the Big Island. The trail begins near a residential area and leads hikers down a dirt road used for maintenance of the ditch. Eventually the trail moves away from the ditch and further up the mountain the trail continues through rain-forest. After 1.75 miles of hiking the reward at the end of the trail is a lookout offering spectacular views of the six waterfalls that flow like ribbons down the back of Waipio Valley. A thin, undefined trail continues into the forest for two miles before fading into scrub land. Users felt the hike to the lookout was relatively easy.

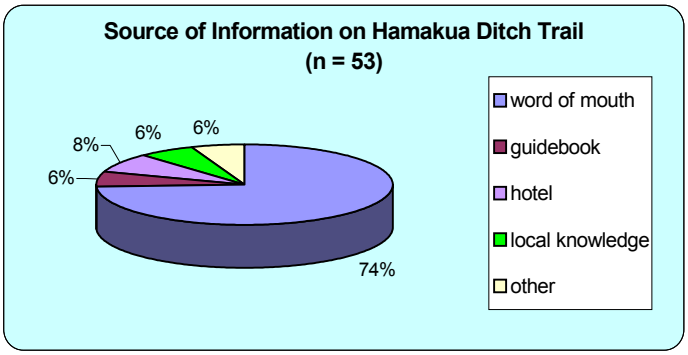
Hazards

Slippery trail
Steep cliffs
Unpredictable weather

Upper Hamakua Ditch User Profile

This is a low to moderate-use trail. The Upper Hamakua Ditch is used slightly more often by local residents than visitors (53% local and 47% non-local), with the majority of hikers learning about the trail from word of mouth. While hikers using the trail ranged in experience level from beginning to advanced hikers, most considered the trail to be an easy to intermediate level difficulty, with almost 70% agreeing their hike was easy. Over half of the people surveyed were hiking Hamakua Ditch for the first time, yet a large percentage had hiked other Hawaii trails. This was a common trend observed by the survey team on the Big Island.

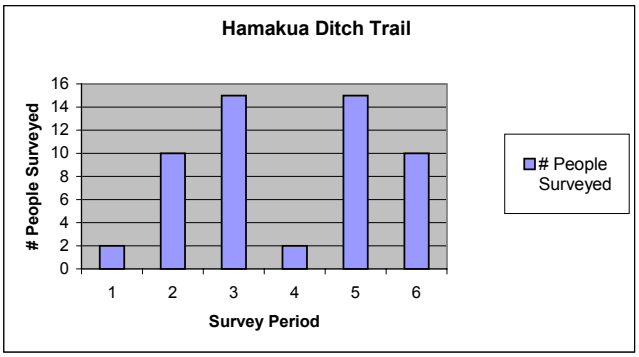




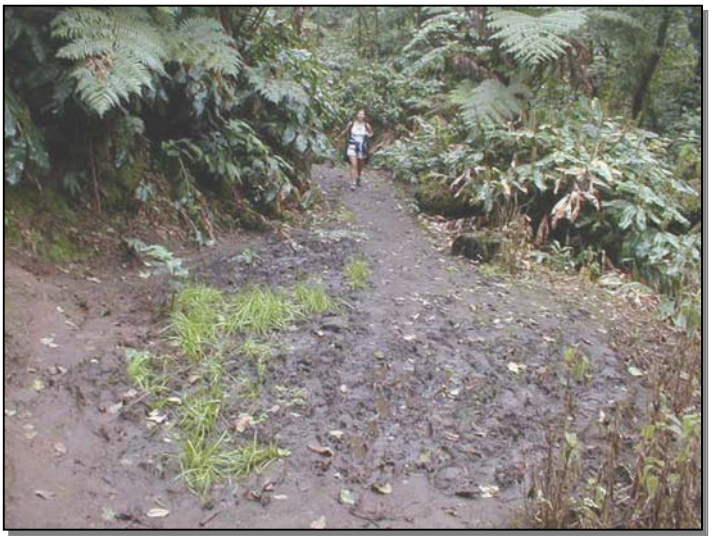
Social Profile of Trail and Trail Users

Survey Period Synopsis: The survey team set up at the lookout. The majority of those hiking the trail were doing so for the views (40%) or to experience nature (42%). Most hikers were interviewed on weekends. Many of the locals who had hiked the trail warned that by noon the trail was usually locked in by fog, eliminating the motivation to hike for the views. Our survey periods confirmed this and found that more people hiked during the morning hours. Over 90% of the hikers interviewed claimed they had stayed on the marked trail, which also matched our observations.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Friday	2:00-5:00pm	2
2	Sunday	10:00-1:00pm	10
3	Sunday	1:00-4:00pm	15
4	Friday	8:30-11:30am	2
5	Sunday	10:00-1:00pm	15
6	Sunday	1:00-4:00pm	10



Trail Conditions: The trail offers little signage information to hikers, except for the several "No Trespassing" signs, which almost 80% of hikers remembered. The trail begins on dirt roads used by the Department of Agriculture to maintain the ditch and the reservoir near the trail entrance. The trail is relatively level, with only minimal elevation gains. The trail surface is relatively flat and primarily top soil. However, with the rain-forest weather conditions prevalent in this area, parts of the trail are often muddy and can be slippery.



Physical Profile of Hamakua Ditch Trail

The Upper Hamakua Ditch Trail is accessed via a State Department of Agriculture (DOA) easement through a Hawaiian Homelands parcel. The road continues through the Kohala Forest Reserve boundary to the ditch itself, which is again the jurisdiction of DOA. Here the path reduces to a single track and meanders along the ditch course for about a half mile, then conforms to the topography while maintaining a moderately level grade. The primary attraction is just under two miles from the parking area, and is a spectacular view of the back of Waipio valley all the way to the shoreline to the north. There is a multi-sectioned waterfall that cascades 1,000 feet to a small pool on the valley floor. The trail continues for another two miles at a level grade around the upper rim of the valley, through a bamboo forest, to an open area where the trail disappears into ginger-`ohia scrub land. "No Trespassing" signs are the dominant management action apparent on the trail, besides its excellent surface condition.

The mean annual rainfall for the ditch trail is 100-120". The elevation gain/loss on the trail course is minimal, and the soils are Kahua silty clay loam (KCD). The erosion hazard for this soils type is slight and permeability is slow, as evidenced by standing water at certain points along the trail. There is no canopy covering. There are four hazards that exist on the Upper Hamakua Ditch Trail: slippery surface, steep cliffs, hazard trees, and the ditch itself.

Trail Surface: Due to the high rainfall and slow permeability of the clay loam soils, as well as to the presence of springs, several sections of the trail remain muddy even after extended dry periods. Some sections of this century-old cobblestone trail have since washed out, leading to deep erosion into slippery, well-packed mud. This is particularly true over the five concrete bridges that span the drainage ways along the ditch valley rim section of the trail. The first overlook point is considerably eroded.

Steep Cliffs: Although the cliff may exceed a 70% grade, most of the area directly adjacent to the trail is of lesser slopes and well-vegetated with ginger, ti, hapuu and other indigenous plants which act as a break to a potentially dangerous fall.

Hazard Trees: In all, there were nine hazard trees observed on the Ditch Trail. Most of these were bargas eucalyptus (*Eucalyptus degulpta*), but there were also ohia (*Metrosideros polymorpha*), paper bark (*Melaleuca quinquenervia*) and avocado (*Persea americana*) observed on the trail. A large eucalyptus near to the primary attraction was down over the trail on (10/7/00) which was standing on the (9/30/00) observation period. As with most trees along the trail before the first overlook, the trunk was moss-covered, which retains moisture and contributes to rot. Seven trees in this stand were leaning directly over the trail and classified as HT2.

Hamakua Ditch: The concrete-lined ditch is a potential hazard, as the constant flow of irrigation water encourages entry by some more adventurous users.

Existing Management Practices: As the trail can only be accessed by passage through Hawaiian Homelands, there are no trailhead signs marking the feature, but there are no trespassing signs. This prohibition is contradicted by the paved parking area and pedestrian-friendly gates encountered along the DOA easement. The only other sign is a forest reserve rule sheet at the reserve boundary. Although it appears intentional for hikers to be discouraged from using this trail, the feature is maintained to a standard of care similar to trails in the Na Ala Hele system.

Possible Action Steps: Despite the number of DOA "No Trespassing" signs, the use of the ditch trail by the public continues. Signage could be installed on the gate at the parking area to inform the user about the trail and its various potential hazards. The trail surface could be improved with minor development similar to the practice used on other Na Ala Hele trails, particularly on the boggy areas and the areas showing heavy erosion from use and weather. The potential hazard trees near to the primary destination might be removed but replaced to preserve the mystic beauty of the forest.

Kahaualea Trail, Hawaii

The Kahaualea Trail is located on the eastern slope of Kilauea Volcano on the Big Island, near Volcanoes National Park. The trail begins in a developing residential area and weaves through the Kahaualea Natural Area Reserve, an area of approximately 16,726 acres. The majority of the trail leads through an ohia-fern wet forest. Eventually the trail reaches an area that has seen recent volcanic activity. The trail concludes at a sign on the lava flow, which warns hikers from continuing due the presence of active lava vents in the area. The trail is a moderate to easy hike measuring approximately 8 miles round-trip.

Hazards

Slippery trail
Uneven terrain
Active Lava Vent
Muddy/Boggy

Kahaualea User Profile

This is apparently a low-use trail since we encountered no hikers during our five survey periods. The lack of activity is due most likely to the lack of information available in guidebooks about the trail. The survey team spoke to two ladies who lived on the road leading to the trailhead who claimed that they frequently saw "rental cars" heading toward the trail. However, because the developing residential area around the trailhead is still mostly empty and the number of cars traveling the road is minimal, even a very small number of visitors might be noticed and remembered.

Social Profile of Trail and Trail Users

Survey Period Synopsis: The survey team set up at the trailhead, which was also at the parking area for people using the trail. No vehicles, besides abandoned cars, were seen at the trailhead. There were signs that someone had been on the trail during the first survey periods, as fresh tracks were visible on the trail. It is possible that overcast and rainy weather conditions were partially to blame for the lack of users on the trail.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Friday	11:00-2:00pm	0
2	Friday	2:00-5:00pm	0
3	Saturday	9:30-12:30pm	0
4	Sunday	11:00-2:00pm	0
5	Sunday	2pm-5pm	0

No users surveyed

Trail Conditions: The trail is identified at the trailhead with a Natural Area Reserve sign. The trail travels through a wet ohia-fern forest, and is relatively level, with only minimal elevation gains. The trail surface is very wet and has been covered in several areas with cut logs for hikers to walk on. However, many of these have not weathered well and are deteriorating. Also, with the rain-forest type weather conditions in this area, sections of the trail can become almost impassable at times. The lava covered section of the trail was a brittle pahoehoe (smooth-textured) variety. It is undergoing rapid disintegration and features lava tube "skylights" and the possibility of cave-ins. Primary vegetal succession (ferns) is beginning to take place on this flow.

Physical Profile of Kahaualea Trail

The Kahaualea Trail is in the Natural Area Reserve Program in the Division of Forestry & Wildlife of DLNR. The trail is a unique physical study as it travels through tropical rainforest for most of the route, which abruptly transforms into a lava wasteland. The recent flow is a product of the active volcanic cone Puu Oo. It is interesting to note that although there was solid forest for most of the route, there were no hazard trees observed. Elevation change is minimal, thus there is no threat of slope failure. The trail is used by hunters, which creates a potential hazard due to the low visibility in the forest portion of the Kahaualea. The mean annual rainfall of the trail area is between 120 and 140". There are no stream crossings and therefore no flash flood hazard. The soils are Keei extremely rocky muck (rKGD) and pahoehoe lava flows (rLW) which are rapidly permeable where soil is present unless bedrock is not fractured. There are three hazards that exist on the Kahaualea Trail: slippery/uneven trail, shared use, and leaving the trail.

Trail Surface: The forest portion of the trail hosts a considerable amount of standing water, up to two feet deep on some trail sections. Although this may be considered a nuisance, it cannot be accurately designated a traction hazard. On the contrary, the depth of the mud may provide too much traction. If a hiker is not attentive to the trail in drier sections, he/she may stumble into one of four fault cracks between 8 and 12 inches wide in the forested section. These cracks cannot be seen until you are directly over them. On the lava flow portion of the trail, lava tube "skylights" may be created through the thin crust of this relatively new (less than 20 years) flow from the hiker's own weight. The trail is not well-defined on the flow, which allows routes to vary and venture onto thin surfaces. A fall on this type of rock can cause serious cuts, sprains, and/or fractures.

Shared Use: The only trail users observed on the Kahaualea Trail were hunters. Hikers should be aware that the area is actively used by hunters with dogs and should also be encouraged to wear brightly colored clothing for visibility.

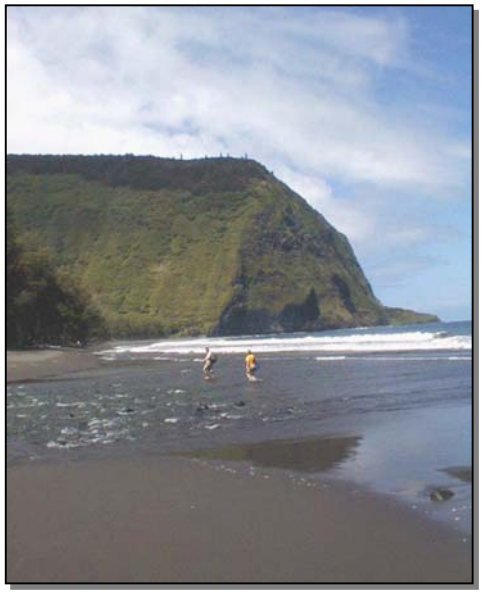
Leaving the Trail: Due to the heavy use by hunters, there are a number of frequently used spur trails, some even as well-defined as the main trail. The pahoehoe portion of the trail is not well-defined and venturing off the trail may occur unintentionally. Although there are ribbons intended to mark the trail, they are placed in an ambiguous position on the junction rather than on the appropriate route. The end of the trail, marked by a prominent yellow warning sign, is a

provocative warning that may encourage some adventurous users to continue up to the active cone. The sign warns of the dangers, the reason for the danger, and that rescue efforts may be delayed.

Existing Management Practices: Aside from the trailhead and end of trail signs, the trail is devoid of information. The trail surface is maintained by placing the fibrous hapuu (Cibotium glaucum) fern logs on saturated sections of the trail. Despite being immersed in the standing water, the hapuu logs appear to be rot-resistant and serve as renewable, long-term trail improvements. Several small ohia trees were down over the trail, and some older subjects had been sawn where they had fallen. Spray painted symbols were observed on the makai-side of the lava rock outcroppings on the lava portion of the trail. This was to assist the hiker in navigating back to the trail where it enters the forest.

Possible Action Steps: Due to the length of the trail, a map near to the trailhead and quarter-mile markers should be installed to assist hikers with their trip management. Warnings about the conditions at the trail destination would be helpful to the user at the beginning of his/her hike. Continued development of the trail surface would be a significant improvement, especially concerning the fault cracks. and Installing a hunter-hiker check-in box would help users to know who and what type of user is on the trail. Directional signs at key junctions would virtually eliminate all unintended venturing from the trail. Ahu should be added to the pahoehoe portion to mark the trail route through this area.

Muliwai Trail, Hawaii



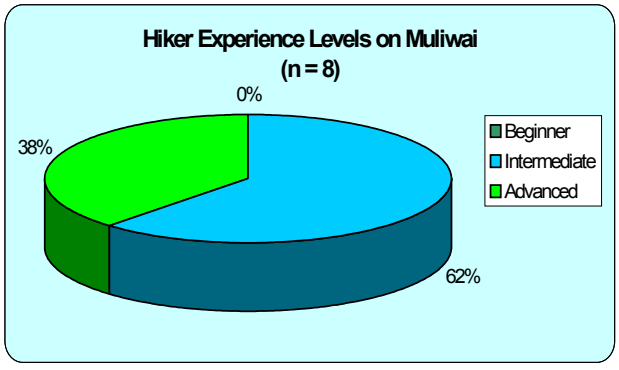
The Muliwai Trail is located on the Hamakua Coast of the Big Island in Waipio and Waimanu Valleys. It is the only land route to the Waimanu National Estuarine Research Reserve. These beautiful valleys are rich in cultural history having supported large populations of Hawaiians in the past. The trailhead starts at the bottom of Waipio Valley, then zig-zags 1,200 feet up the west wall to the plateau between Waipio and Waimanu, before crossing twelve gulches and descending into Waimanu Valley. Vehicle access into the valley is by 4-wheel drive only. The trail is a challenging 15.3 miles round-trip.

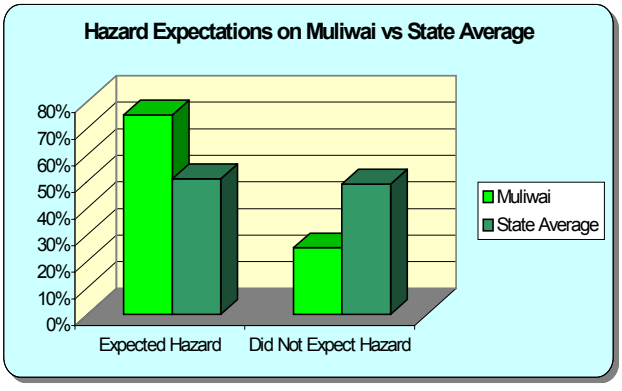
Hazards

Slippery trail
Stream crossings
Steep cliffs
Unpredictable weather

Muliwai User Profile

This is a low-use trail, due most likely to the challenges in reaching the trailhead and the difficulty level of the trail itself. The trail was found to be used primarily by visitors (12% local and 88% non-local). Hikers using the trail considered themselves either experienced or intermediate level hikers. Information about the trail was gathered by hikers mostly from guidebooks (50%) or word of mouth (38%). Most hikers said the trail met their expectations or was slightly more difficult than expected. Almost 90% of the people surveyed were hiking Muliwai for the first time, however almost that same percentage had hiked other Hawaii trails.

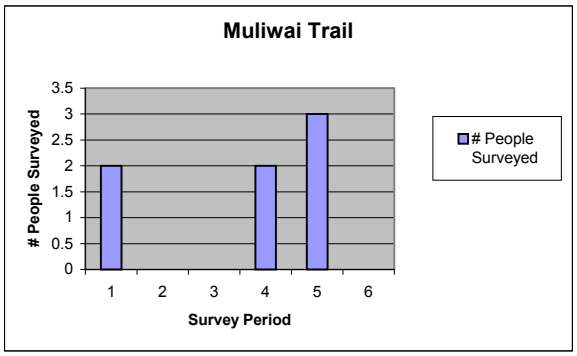




Social Profile of Trail and Trail Users

Survey Period Synopsis: The survey team set up in a clearing approximately 30 feet before the trailhead. The majority of those hiking the trail were doing so for the views and exercise. Some people who hike the trail do it over several days, spending a night camping in Waimanu Valley before hiking out. The locals that were interviewed on the trail were using it for hunting, and had spent two days camping on the trail. The highest uses were recorded on the weekends. During survey periods, some residents of Waipio Valley stopped to talk to the interviewers. They expressed that most hikers seen on the trail were noticed exiting on Sundays. Half of the hikers interviewed admitted to leaving the marked trail.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Friday	10:00-1:00pm	2
2	Sunday	10:00-1:00pm	0
3	Sunday	1:00-4:00pm	0
4	Friday	1:00-4:00pm	2
5	Sunday	11:00-2:00pm	3
6	Sunday	2:00-5:00pm	0



Trail Conditions: The trail is signed along the route, however the trailhead signs have been defaced and offer little to no information to hikers. Remarkably, seventy-five percent of hikers remember signs along the trail. The trail is rugged but generally in good condition, considering its length and remoteness. With unpredictable weather conditions the trail can become muddy and slippery when wet. Erosion has aggravated the ledge in some places and hikers commented on the difficulty of navigating these sections. While some of the trail is sheltered from the elements by a forest canopy, much of the trail puts hikers in extreme exposure to sun, wind and weather. One hiker mentioned he had trouble with bees on the trail.

Physical Profile of Muliwai Trail

The beginning of the Muliwai Trail is a gradual incline on the northern wall of Waipio Valley through a noni (*Morinda citrifolia*) forest with a high canopy. This abruptly changes into an exposed trail at a sharp slope. The last portion of the switchback is also tree-covered, but the majority of this section receives full sun exposure in the morning and early afternoon. At the top, the trail enters an ironwood (*Casuarina equisetifolia*) forest. Mosquitoes are a nuisance for the entire length of the trail. There are four emergency helipads along the route, which also show the distance to each endpoint. The shelter is located between the 10th and 11th valleys, at the third helipad. At the base of the switchback is a well-weathered sign indicating that permits are needed to camp in the valley, and where they can be obtained. There are seven significant stream crossings, including the Wailoa (Waipio) and Waimanu streams. The latter two streams are not technically on the trail, but must be forded to access the trail from either end. There are five potential hazards that exist on the Muliwai Trail: slippery surface, hazard trees, exposure/fatigue, rockfall and flash flooding.

Trail Surface: Considering how remote the trail is to populated areas, the trail is in excellent repair. The only hazardous section worthy of mention is the switchback into Waimanu. This is "rough broken land" (rRT), described in the USDA Soil Survey of 1973 as "very steep, precipitous land broken by many intermittent drainage channels. It occurs primarily in gulches and the slope is dominantly 35-70%." The loose soils make for a challenging descent into Waimanu. The trail between switchbacks is of lesser difficulty and stretches for some 5 miles with relatively low potential risk. Stream crossings have partially submerged rocks that may be moss-covered and slippery. Waimanu and Wailoa streams also feature moss-covered stones in their courses.

Hazard Trees: Most of the Muliwai Trail and the Waimanu switchback are under forest canopy. Some of the largest trees in the state are found along this trail in a wide assortment of species. For the distance of the trail, there were few potentially hazardous trees observed. Although hala is not generally considered a hazard tree, a few were observed down over the Waimanu switchback. There were seven potential hazard trees in three varieties: ohia, albizia, and tropical ash. They were rated between HT2 and HT3.

Climate & Topography: The lengthy Muliwai Trail, between 7 and 9 miles depending upon the actual starting point, is a strenuous hike only to be attempted by hikers who are experienced

and prepared to stay overnight. Potable water is not available on the trail, so water found on the trail must be purified prior to consumption. The 1,200-foot switchbacks on either end of the Muliwai are challenging.

Rockfall: The potential for slope failure is severe on both switchbacks and in two locations along the middle portion of the trail. This is due to the steep slopes, high annual rainfall, and the rough broken land soil classification. Rockfall hazards on switchbacks multiply by the number of switches below the origin of the rockfall.

Flash Flooding: Although there are five stream crossings on the Muliwai Trail itself, it is the Waimanu and Wailoa streams that pose the greatest flash flood hazards. Both streams are crossed in the shallow areas near to their mouths where the volume of flow is greatest, and due to the 120-160 inches of annual rainfall in the back of these windward valleys, stream level rise can occur very rapidly. This could prevent campers wishing to return either from Waimanu or back over the Wailoa. Despite the normally small size of the Muliwai streams, they can nonetheless become impassible during times of heavy rainfall.

Existing Management Practices: The trail is maintained every three months by DOFAW personnel. These efforts do not include the removal of larger trees, and many can be seen partially blocking the trail course. Signage is minimal and assumes that users are well-informed and prepared to attempt the trail. The signs at either end of the trails are in disrepair.

Possible Action Steps: The hazardous trail surface on the Waimanu switchback is undergoing constant natural changes in addition to the occasional erosion caused by the passing backpacker. It would be difficult to improve the condition of the trail without extensive construction or trail realignment. There are sections where intermittent vertical drainageways that have sliced through the trail have been cemented over, yet erosion eventually eats around the repair. A discreet caution sign at the top of the switchback could alert the user that a change in conditions is ahead without forsaking the natural integrity of this primitive trail. Hazard trees are not widespread on the Muliwai, but trees could be monitored during the scheduled maintenance trips. A trail information sign at the Waipio-side trail head could include warnings about trees as well as precautionary statements about flash flooding, fatigue and the possibility of rockfall.

Island of Maui

The Practicum group met with Curt Cottrell, Na Ala Hele Program Manager and Mark Peyton, Na Ala Hele Maui Trails Technician on September 8, 2000 to discuss the scope of the evaluation on Maui.

The following trails were proposed for consideration for survey purposes:

- Waikamoi Ridge – high use trail; primarily used by visitors en route to Hana; several users believe a waterfall exists along the trail; concern about users going past end of trail sign to East Maui Irrigation property in search of waterfall; parking and traffic congestion; slick trail with mud, roots; eucalyptus robustus trees
- Waihee Ridge – moderate use trail; primarily local; bench located nearly one mile in, with sheer drop off in front; slick muddy trail with steps in some locations to improve; fence at end with signage to prevent going further; steep cliffs on ridge line
- Waihou Springs – family trail; springs; erosion; rockfall
- Polipoli – busy area on weekends; multiple trails so use on each trail likely low; survey of cars would be interesting

There were no state parks suggested for survey purposes.

The trails selected were Waikamoi Ridge trail and Waihee Ridge trail. These trails were on opposite end of the windward side of the island and had totally different user types and user levels. While Waikamoi Ridge is on the route to Hana and attracts the curious because of the cars parked, Waihee Ridge is outside of Wailuku in a relatively quiet area. Additionally, Waikamoi Ridge trail is short enough to do in 1 hour and has little elevation gain; Waihee Ridge trail is 2 ½ miles long and has a 1500 foot elevation gain, with a significant portion in the first quarter mile. Because of the significant difference between the trails, it is not possible to discern any trends among users on Maui.

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Waihee Ridge Trail, Maui

This trail traverses a 2.5 mile, uphill course in the West Maui Mountains, affording incredible views of Wailuku, Haleakalä and the lush Waihee Valley. The gradual 1500-foot climb takes hikers from pasture, through dry, low-land forest, all the way to the misty and cool climate of the peak.

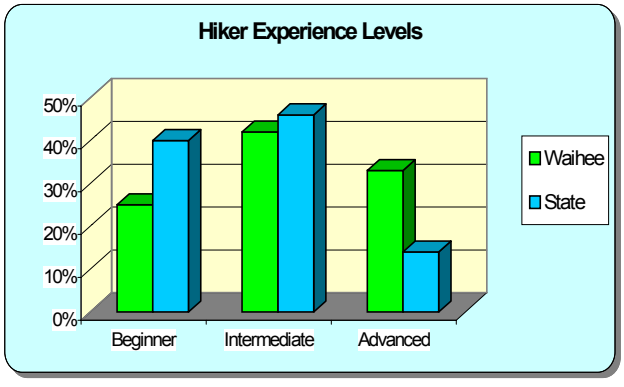
The Waihee Ridge Trail is unique as it hosts dozens of rare plant species known to exist only in Hawaii, and some only on the Waihee Ridge. The majority of the people surveyed felt this was an intermediate hike.

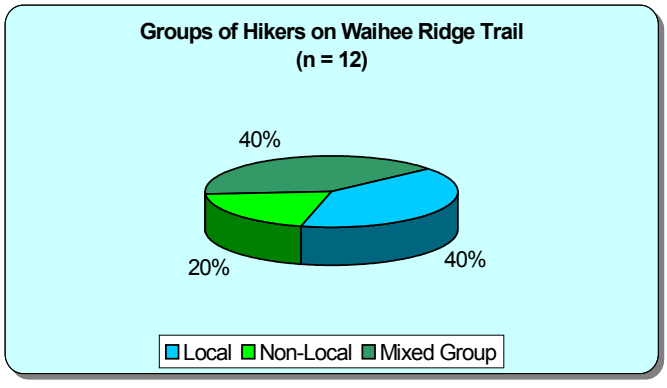
Hazards

Rapid changes in weather conditions
Fog/heavy rain/sun exposure
Semi-rigorous climb
Slippery and boggy trail
Off trail: steep cliffs, sink holes

Waihee User Profile

This is a low use trail, visited primarily by local hikers (66% local). The highest uses occurred on the weekends. Most Waihee Ridge trail users are well prepared and are relatively experienced hikers (71% were intermediate or advanced hikers). Generally hikers felt the trail was in good condition and felt it should be maintained as is.

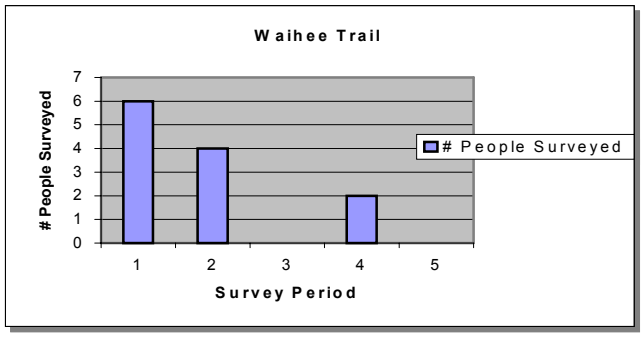




Social Profile of Trail and Trail Users

Survey Period Synopsis: The survey team set-up at the parking area for the Waihee Trail. This is a low-use trail with an average of 2.4 hikers surveyed each 3 hour survey period. However the use is likely variable. One Practicum member, while hiking Waihee Trail on personal time on Thanksgiving Day, reported encountering twenty-four people hiking the trail between 11AM and 2PM. Many of the hikers are local and often visitors are accompanied by a friend who is a Hawaii resident.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Saturday	9:00-12:00pm	6
2	Saturday	12:45pm-3:45pm	4
3	Friday	3:30-6:30pm	0
4	Saturday	8:00-11:00am	2
5	Saturday	11:00-2:00pm	0



Trail Conditions: The trail surface begins as a paved roadway to a water reservoir. The trail turns into a grassy path that must be mowed on a regular basis. At the end of the grassy path, hikers must scurry over a fence before entering the part of the trail that is on State land. From the fence, the trail is a dirt path which can be muddy and gnarled by tree roots, but generally the path is wide and clear. Stairs have been placed to assist in climbing the steeper portions of the trail. Signage consists of identification of the trailhead, mile markers at half-mile intervals, stay on the trail signs, and an end of trail sign at the picnic area at the top of the ridge. Several groups expressed appreciation for the trail's good condition and continued maintenance.

Physical Profile of Waihee Ridge Trail

The Waihee Ridge Trail begins on a concrete surface for the first quarter mile, then branches off into a low-cut path through pasture. After climbing over a fence , the trail enters a wooded area predominated by tropical ash (*Fraxinus uhdei*). A bend in the trail affords a view of a waterfall in the adjacent Makamakaole valley. The brief canopy opens up and narrows to a moderate ridge that passes through smaller tree stands. The end of the trail is a high point on the ridge furnished with a picnic table and sweeping views of north-central Maui, the West Maui Mountains, Waihee stream, and the Pacific ocean to the north. Surrounding the trail terminus is an abundance of native plant species. The mean annual rainfall for the trail area is 40-80 inches. The dominant soil type for the area is Honolua silty clay, which is classified as a moderate erosion hazard. Though there are forested areas, there are no significant individual tree hazards with an aspect toward the trail. Limbs of tropical ash, *eucalyptus rudis*, and paper bark (*Melaleuca quinquenervia*) are generally hazardous tree types, but posed no significant threat on this trail. The trail is impeccably maintained and features high-quality stairs that have been recently installed near to the end of the trail. There is only one boggy area on the trail on the level portion just before the stairs. Although this trail is relatively hazard-free, three potential hazards could be considered for the purposes of this study: steep cliffs, leaving the trail, and climate and topography.

Steep Cliffs: A potential hazard at the 1-mile point where a bench has been constructed is near to a cliff-overlook into Waihee valley. To prevent users from going near to the edge, a simple wooden guardrail may serve to reduce that hazard without detracting from the view. The trail has some steep sections that used to get very slick during rainy weather. Recently, recycled plastic/wood steps were built for improved stability and to reduce the little erosion activity that might occur on this trail.

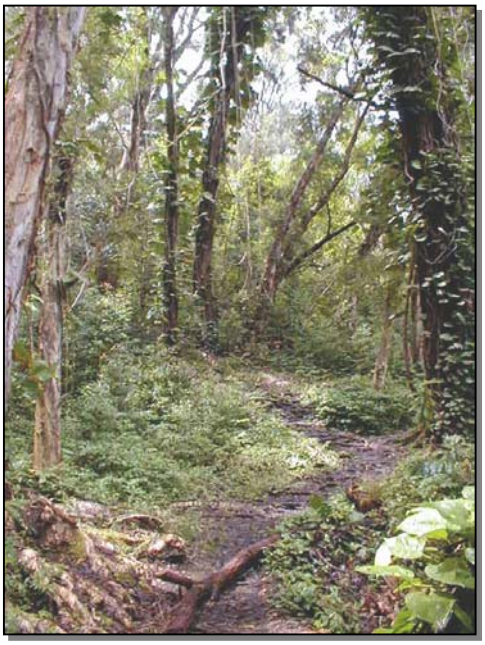
Leaving the Trail: There are a few spur trails along the route that venture from the trail toward the edge of Waihee valley, as well as at the end of the trail. They run through patches of heavy Uluhe (*Dicranopteris linearis*) that may conceal uneven terrain and a possibly eroded or saturated trail. Fortunately, Uluhe may quickly regrow if not trodden upon, which offers a good opportunity for restoration.

Climate & Topography: The trail is a steady climb to about 2560 feet in elevation. Although there are scattered stands of forest over the trail, the majority of Waihee Ridge is exposed to the elements. However, being a remote destination trail, users intending to attempt the entire trail appear to arrive prepared to hike.

Existing Management Practices: Signs include mileage markers and directional arrows. The trail was in excellent condition throughout the majority of the trail, and signage was discreet and effective.

Possible Action Steps: There are very few recommendations that can be made regarding the natural or built characteristics of this well-maintained trail. The boggy area before the series of stairs at the end of the trail could be improved by placing logs, a short boardwalk, or stones over the saturated area.

Waikamoi Ridge Trail, Maui



The Waikamoi Ridge Trail is located on the Hana Highway about 10 miles after the road begins its twisting and weaving in and out of the valleys. This trail is one of the few places where the public is invited to enjoy the lush rainforests of East Maui. The trail is a loop with a spur to an overlook and picnic area. The entire trail is less than two miles and takes about 30 minutes to walk the main loop. Many of the plants are marked with species identification signs and the flora's origin.

Most of the people surveyed felt this was an easy hike and many people were glad to have an opportunity to get out and stretch their legs in a beautiful nature hike.

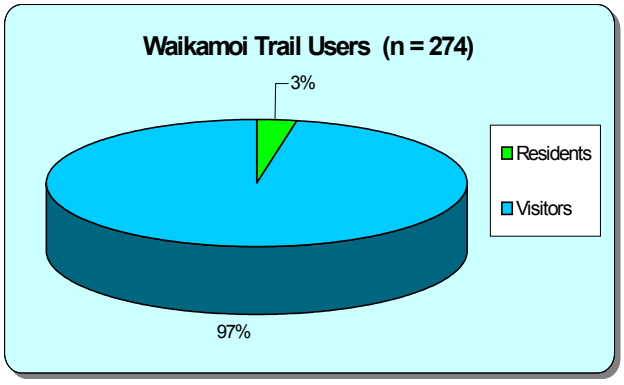
Hazards

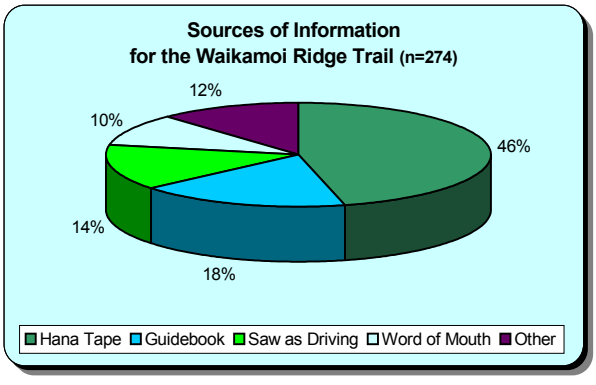
Hazard Trees

Slippery Trail

Waikamoi User Profile

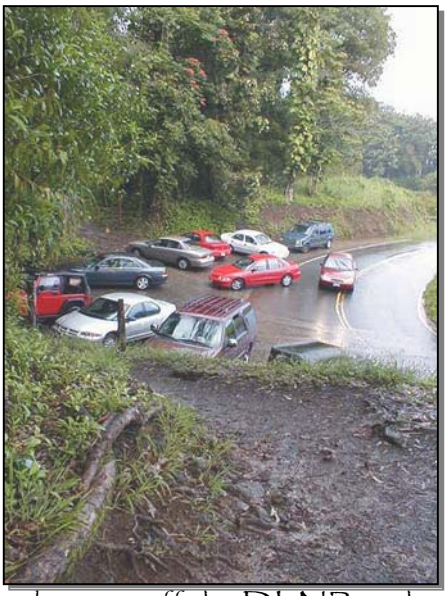
This trail is used almost exclusively by visitors to Maui, with only three percent of those hiking from the island. Most users did not plan to hike when they stopped at this trail. It seems that this is a convenient stopping point in the trip to Hana. Many people learned about the trail from the "Road to Hana" cassette tape that is sold all over the island.





Social Profile of Trail and Trail Users

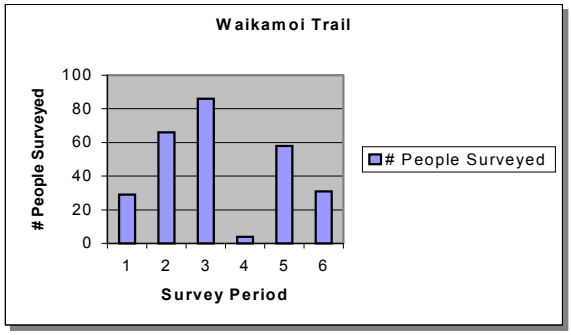
Survey Period Synopsis: The survey team set-up at the picnic are near the trailhead. There are two methods to access the trail from the parking lot. The first is to enter next to the trail sign by a path which passed the survey area, but the other method does not pass the survey area.



This probably caused several groups to go uncounted. The volumes of hikers seemed to be relatively consistent on weekdays and weekends. Weather and time of day seemed to be the factors that most directly affected whether people hiked or not. The parking area became easily and frequently congested.

The majority of the people stopping learned about Waikamoi Ridge Trail from the Driving to Hana tape. This tape characterizes the trail as an "easy stroll through a beautiful forest" and mentions that there is a waterfall on the trail. In fact, there is no waterfall on the trail, rather the falls are quite a distance off the DLNR path on East Maui Irrigation property. Despite the enticing claim of a waterfall, the impression of the survey team was that very few people were leaving the trail to search for the falls. The few people that said they did were locals who either knew about the falls or were gathering for cultural purposes.

Survey Period	Day of Week	Survey Time	# People Surveyed
1	Friday	12:45-3:45pm	29
2	Sunday	8:45-11:45am	66
3	Friday	10:00-1:00pm	86
4	Friday	1:30-4:30pm	4
5	Saturday	9:30-12:30pm	58
6	Saturday	12:00-3:00pm	31



Trail Conditions: People liked the species markers and commented they would like to know more about the plants. Several people liked the gravel at the beginning of the trail and thought it would be helpful to continue this or mulch, the length of the trail to increase traction and improve footing. Many people commented that they could not get to the bamboo forest portion of the trail and requested a directional sign at the stone bench where the trail switchbacks. Several requests were made to add a comfort station to the park.

Physical Profile of Waikamoi Trail

This trail is unique to this study because it is a double loop trail, and because the destination (the waterfall) cannot be seen from the designated course. It is in a heavily forested area, and there are a number of hazardous trees. It is a well-developed trail with an elevation gain of approximately 200 feet over the length of the .5 mile trail. The soils in the area are predominantly Kailua silty clay (KBID) with rough mountainous land (rRT) nearer to the eastern extent of the trail. These soil types possess only slight erosion hazards and water tends to stand on compacted soil. The mean annual rainfall is around 100 inches. There are no stream crossings on the trail and no hazards related to slope on the designated trail. There are three hazards that exist on the Waikamoi Trail: hazard trees, trail surface, and leaving the trail.

Hazard Trees: A heavily wooded trail, there are several magnificent introduced and native tree specimens on the Waikamoi loop. As the forest trees mature, the degree of hazard they present increases. There were 22 potentially hazardous trees observed on this trail, all of which were introduced species. They included eight *eucalyptus rudis*, eight *eucalyptus robusta* and six paper bark (*Melaleuca quinquenervia*). Other trees observed on the trail included koa (*Acacia koa*), guava (*Psidium guajava*), strawberry guava (*Psidium cattleianum*), kukui (*Alleurites mouccana*), mango (*Mangifera indica*), and hala (*Pandanus tectorius*). Most of the hazard trees are in fair condition due to broken limbs, so total removal would not be a necessity. Due to the comprehensive high canopy, there will likely always be a baseline HT4-5 situation along the Waikamoi Trail.

Trail Surface: Especially along the lower portion of the loop, the trail surface holds water and is characteristically muddy. Moderate inclines can be hazardous, but due to the setback of the trail from any steep slope, the extent of a slip and fall would result in a sprain or minor fracture. These conditions only occur in a few locations, with the remainder of the trail in excellent condition. Stairs have been constructed in certain areas. Areas along the east portion of the trail feature root-covered surfaces.

Leaving the Trail: Cassette tape tours describe the Waikamoi Trail as having a waterfall as an attraction for this trail. This feature exists beyond the clearly-signed "end of trail" on the property belonging to East Maui Irrigation Company (EMI). Users hopeful for the scenic attraction may continue beyond the end and expose themselves to additional hazards related to the stream, as well as additional hazard trees and unmaintained trail.

Existing Management Practices: Signage is limited to a crude wooden map at the trailhead, the stay-on and end-of-trail signs, and the comical "quiet – trees at work" sign. There is also a warning sign at the trail terminus. There are no distance signs on this short hike, and only one directional sign to direct users away from the EMI access road. There are some wooden stairs on some portions of the loop, and gravel has been placed on the lower end of the loop to curtail the effects of a muddy trail.

Possible Action Steps: A routine tree inspection and maintenance program is recommended at Waikamoi due to the large number of hazard trees. Most would not require complete removal, and complete mitigation of high tree hazards will prove to be difficult. Due to the high use and inclement weather, particularly high winds, a program should be suited specifically to the unique characteristics of the Waikamoi Trail. Stair development could be extended to the lower, high moisture areas of the loop. This trail could be planned and managed as a wayside stroll rather than a nature hike, as this is what it is used for. Finally, the commercial Hana tape should be modified to say that there is no waterfall at the end of this trail.

Prior Event History

History of rescue events give an indication of the type and severity of risk at a location. At this time, there is no statewide standardized system of notification or reporting that ensures that the State is notified when a search or rescue operation occurs on state land.

A review of the media reports for the year 2000 demonstrates that search and rescue operations occur on a regular basis (See next page). The rescues reported in the media are only a fraction of the total rescues, however; an April, 2000 Honolulu Star Bulletin article reported that the Oahu Fire Department had nine rescue missions for lost, stranded or missing hikers in the past month, but only two of these rescues were reported in the newspaper.

In addition to issues of public safety, search-and-rescue operations entail significant costs to the counties and to the State. Two methods of estimating costs might be the following examples. The Fire Department allows film crews to rent equipment and fire fighters for movies. Utilizing costs of $538/hr for helicopter and pilot and $252/hr for fire engine and five firefighters, the total expense of a rescue mission could be estimated as $1700 per rescue. (4/7/00, Honolulu Star Bulletin). After two consecutive helicopter rescues at Wailua Falls in July, 2000, Kauai County announced that it would begin to charge for the costs of rescue for those who jump from the Falls, estimated at $1500 for helicopter and personnel (7/10/00 Honolulu Star Bulletin).

Date	Location	Incident
1/18/00	Kahana Valley, Oahu	Helicopter rescue of 2 20 year old males and 14 year old girl from Kahana Valley after dark after being stranded on the ridge when darkness fell
1/19/00	Wahiawa, Oahu	Fire personnel respond to 911 call to rescue 33 year old female hiker off Puamoho trail
2/20/00	Manoa Falls, Oahu	Fire personnel rappel to rescue of 23 year old who wandered off Manoa Falls trail and was trapped on cliff after other hikers call 911 on cell phone
3/17/00	Kipahulu, Maui	Firefighters, police and ambulance assist in rescue of 22 year old Canadian woman who fell off ledge while hiking in Cosmic Gardens area; injuries include head, thigh and elbow
3/25/00	Pali, Oahu	Fire crews hike to 22 year old man, rappelling without proper equipment and rescue him from cliffs near Pali lookout; slight injuries (no hospital treatment)
3/29/00	Kahana Valley	Helicopter rescue of California couple (ages 40 & 62) left the trail in Kahana and were lost for 4 days; rescue efforts began when resident noticed rental car had not moved; couple had left map and water in car
3/29/00	Alakai, Kauai	Helicopter rescue of young couple (21 yr Honolulu female; 22 yr Az male) lost in Alakai Wilderness for 3 days; in good condition - had rationed food and moved to high ground; rescue efforts began when family who knew of their plans saw they did not return
4/24/00	Mokuleia, Oahu	Helicopters and fire personnel searched on foot and found 50 year old Iowa male at base of 400 foot waterfall after hiking up Kealia trail; rescue efforts began when missed rendezvous with son; severe trauma indicated fall caused death
6/27/00	Wailua Falls, Kauai	Helicopter and fires personnel rescue 2 22 year old California men seriously injured jumping off Wailua Falls (200 ft)
6/28/00	Wailua Falls, Kauai	Helicopter and fire personnel rescue 22 year old California man who slipped and fell over Wailua Falls; man swam to side; man was unaware of incident day before
7/3/00	Aiea Loop Trail	Helicopter and firefighters search for 2 women and 1 male who failed to return from early evening hike at Aiea Loop, trio left trail to go see a waterfall and got lost; reported missing 9:30 pm; hikers escorted out at 2:00 am; no injuries
7/4/00	Manoa Valley	Helicopter rescue of 24 year old male resident who fell from rope ladder along Waiakeakua Stream in Manoa Valley in response to 10 year old nephew 911 cell phone call; suffered head & leg injury and shock
8/29/00	Wailuku, Maui	Fire personnel and divers search for 15 year old male visitor last seen at top of falls, found drowned at base of waterfall near Kailua Stream
9/22/00	Kahana Valley	30 searchers, in 4 teams, and helicopter search for 35 year old visitor hiking on Puu Manamana trail; man fell 200 feet and cut knee and was alone for 43 hours; rescue efforts began when police noticed rental car parked alongside of road
10/2/00	Volcano, Hawaii	43 year old Colorado man discovered dead a mile beyond end of Chain of Craters road; cause of death unknown
11/6/00	Volcano, Hawaii	2 hikers (41 year Volcano female, 42 year DC male) found dead of burns near lava flow; actual cause of death unknown
11/27/00	Olomana Cliff Trail	Fire rescue helicopter and rappellers from helicopter down cliff rescue 22 year old Marine injured after fall from sheer cliff at Olomana; rescue efforts began when other hikers heard shouts for help and called 911; appeared to have suffered head, shoulder and leg injuries

Insights Gained and Lessons Learned

Throughout the course of the project, discoveries were made and insights accumulated about the parks and trails systems, the process that regulates them and the people that oversee them. This section communicates those insights and evaluates both the general process and the details of the project.

Insights

Maintenance: Na Ala Hele and State Parks, with very limited financial resources, have been maintaining trails and providing access to public land for recreational users. Time and time again the survey team received comments from appreciative users about the fabulous condition of the trails and the wonderful variety of trails the system offers. Regular hikers noticed the recent improvements that have been made, such as the construction of handrails and steps and the addition of gravel to certain trails. All the comments were very positive and many people felt the improvements were tastefully done without interfering with the beauty of the natural environment.

Signage and Information: Throughout the course of the study, it became clear what types of signs users acknowledge and those that they disregard. On trails that featured distance markers, almost every hiker mentioned they remember seeing the mileage signs. This became a pattern for signs placed near knee height and just off the edge of the trail. Most of the time, when people are hiking they are looking at the trail surface and not necessarily at their surroundings. This, of course, adds to any hazard because in addition to not seeing the hazard, they are not seeing the signs that indicate the presence of hazards.

From our observations, a well signed trail would include:

- mileage markers
- all signs placed low to the ground
- signs consistently lettered and on consistent material
- sign text should be simple and succinct
- good directional signs, especially at unclear switchbacks and trail junctions
- distances listed on directional signs with average hiking times

- short descriptive sign at the trailhead

The survey team noticed that people often do not stop to read signs at the trailhead because they are anxious to get hiking. The team thought hiker check-in stations would be helpful for several reasons. First, the check-in can act as a system to track how many people are on the trail and a method to contact the appropriate people in the event of an emergency. Secondly, a check-in station requests that people stop before entering the trail. A sign reading "Please check-in" would be simple and immediately request that people be responsible for themselves and their presence on the trail. Finally, while they are stopped to sign in, they may be a captive audience for information placed at or near the sign-in station. Making this a routine at each trailhead, where possible, would be a positive improvement that several users suggested for improvements to the system.

Establishing a format for people to give their comments and a number to notify trail managers in case of a hazard event or to report inappropriate use would be very helpful. Many people feel a sense of ownership for the trails as they perform minor maintenance when they hike. This could be built upon and strengthened if users were given a formal process by which to make suggestions and play an important and neighborly role in the trail maintenance.

The survey team felt it is crucial to develop a uniform signage system throughout the islands. Some signs appear very official and others come across as if they were made in someone's garage. Both serve the purpose of offering information but since signs are not consistent, users are not sure what to be looking for. Consistent signage across all state attractions with uniform lettering, shape, size, and material would improve users awareness that the signs even exist.

Information extends beyond just signage on the trail. Some suggestions survey team members had were:

- a website
- new flier about hazards
- comprehensive map production and distribution

Communication: In general, it appeared from the survey team's observations that improved communication would greatly benefit hazard mitigation efforts, trail improvements and maintenance, and rescue missions. The efforts being made on each island varies significantly. Each of the islands are doing things that seem to be very helpful and appropriate for their trails,

yet each island has areas that are in need of improvement. Integrated inter-division DLNR program meetings to share the efforts and respective issues on each of the islands, including success and challenges, would appear to be a very positive resource.

In addition, it seems the communication between DLNR branches and County Fire and Rescue could be improved. When a rescue mission has to be made, the trail manager should be notified immediately. In many cases the trails maintenance team knows the trail very well and could assist in informing rescue personnel of possible hazards to the rescue team, areas of concern and locating victims of accidents.

Commercial Activity: Commercial activity was not a problem on the majority of the trails surveyed; commercial activity was significant at Diamond Head and Manoa Falls only. Users on the whole appeared to accept commercial groups utilizing the trails for hikes, as long as the group size was not too large. Commercial vendors, on the other hand, were uniformly disapproved of by users. The predominant feeling was that sales of water and t-shirts was inappropriate in a natural setting. Many expressed their disappointment at seeing the "literature" distributed by the commercial operator littered along the trail.

Lessons Learned

The information acquired from this study has been helpful in determining what types of uses are occurring on the trails, who is using the trails, which trails are getting the most use, and when the uses are occurring. All of these elements aid in determining what might be done to improve the trails system and reduce hazard potential. With some reorganization and modifications to the process and details, this could be an incredibly helpful ongoing program for DLNR.

In using this study as a pilot project for a larger and more comprehensive evaluation, the following modifications are suggested.

Process Modifications:

- Be consistent with the number of surveyors at each trail- in some cases on high-use trails, the number of surveyors varied from survey period to survey period. This gave an inaccurate reading of the number of people actually on the trail during a given survey time. To improve accuracy for comparative purposes, the number of surveyors at every trail during every survey period should be consistent.

- Be consistent with number of survey periods at each trail and the time periods at each trail. On some trails, the team was not able to complete all six survey periods because of time constraints. To get an accurate, comparative reading the number of survey periods between trails should be the same. Time periods should be designated such as 6AM to 9AM, 9AM to noon and so on. The team got in the habit of starting the survey period upon arrival to the trail. It was convenient for the team since the time period for the study was so limited, however, it offered no ability to compare one survey period to another in terms of the time the surveys were taken.
- Be sure an official count is taken of the number of hikers entering the trail. This was done by the survey team during a few survey periods but was not uniformly applied as a part of the process. On high use trails, it is not possible to ask everyone to do the survey and many times people refuse. To get a better idea of how many people are actually on the trail, an official count should be taken by someone at each trail.
- A better system of trail selection should be established. Trails were selected on each island with no clear framework for why one trail was more important than another to survey. Some trails seemed to be naturals because of high use and known hazards. Other trails, such as Ainapo on the Big Island were selected because of a recent incident, however no people were surveyed on the trail and it is likely that very, very few people go to the trail because of the difficulty of reaching the trailhead. Unless a future project undertakes an assessment of every trail in the system, a better process for selection should be established.

Changes recommended for survey form:

- Create a question that asks if the user goes into the water where there are streams, beaches and waterfalls. This could give DLNR an idea of who is getting in the water and for what reasons.
- Recognize that if the survey team asks the users' experience levels, that the answer is their own opinion and cannot necessarily be compared to another user's level of experience.
- Add a 1-10 scale for how informed the users felt they were for the conditions they encountered.
- Ask how long the hike took the user
- Create trail specific locations for the "How far did you hike" question. For example in Pihea this meant 1) To the vista, 2) Into Alakai Swamp 3) To Hanalei Lookout, 4) Before Vista.

- The question about footwear is somewhat inconclusive. Depending on the user's comfort level and trail conditions, almost any shoe could be appropriate for a hike.
- When asking the level of difficulty, users wanted to answer in a 1-10 scale.
- Add Hispanic as a category for ethnicity and combine some of the other options.
- Add sunscreen and bug repellent to "What did you bring with you?" question.
- Ask actual age of hikers and not place them in a category.
- Ask actual number of times people hiked in last 30 days and not in a category.
- High use trail surveys should include:
    - "How many times have you been hiking in the last 30 days?"
    - "How far did you hike?"

Eliminate the following questions:

- "Are you regularly active"- this was included for the Department of Health (DOH) and is unnecessary for trail evaluation. Survey team members got the impression that people were a little confused by the question and some were not honest in their answers.
- "What other types of activities do you enjoy?"- this was included for DOH and is not relevant to trail assessment.
- "How many hours per week do you exercise?"-DOH
- "Do you smoke?"- DOH
- "What was your primary reason for going hiking today?" - Many people did not know how to react to this question. The information was not conclusive and not consistent enough to compare between trails or even between users on the same trail.
- "Other Activity"-This was included in the event that people were doing something other than hiking on the trail. The trouble is, if they are actually performing another activity, then the survey is not applicable to them at all. When someone, like a hunter, was on the trail for a reason other than hiking, the survey team recorded this in survey period notes.
- "Have you ever been lost while hiking?" - Most people did not know what was meant by lost. This was not conclusive.
- "Occupation"- This question does not do anything to describe the types of hikers on the trail and is not conclusive.
- "Did you leave the trail today?" People rarely said they had left the trail, although the survey team was often informed by other users that people were leaving the trail. This question was inconclusive.